ILLUSTRATIONS OF
SURGICAL TREATMENT

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ILLUSTRATIONS OF
SURGICAL TREATMENT
INSTRUMENTS AND APPLIANCES

BY
ERIC L. FARQUHARSON
M.D., F.R.C.S.E., MAJOR R.A.M.C.
FORMERLY CLINICAL TUTOR AND TEMPORARY ASSISTANT SURGEON
ROYAL INFIRMARY OF EDINBURGH

With a Foreword by

SIR JOHN FRASER
M.C., M.D., CH.M., F.R.C.S.E.
REGIUS PROFESSOR OF CLINICAL SURGERY
UNIVERSITY OF EDINBURGH

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To

W. J. S.

to whom I owe so much

this book is dedicated

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PREFACE TO THE SECOND EDITION

THE demand for a second edition of this book has afforded a welcome opportunity for revising and amending both text and illustrations. The first edition was actually being printed when War was declared, and by the time it was bound much of Part I, dealing with saline and blood transfusion, was already out of date, for, with the establishment of blood transfusion services in all parts of the country, new types of apparatus and far-reaching changes in technique had been evolved.

In order to bring the book up to date, Chapters I and II have been re-written, while the remainder of the text has been thoroughly revised. Some of the more recent methods of treatment are described, and over eighty new illustrations are incorporated. Nine plates have been added to the instrument section, which is now presented in the form of an Appendix.

In the taking of upwards of a hundred and fifty photographs, from which the new illustrations have been selected, I have made many calls for assistance on those with whom I have been associated during military service. To my colleagues of all ranks in the Royal Army Medical Corps, to the Sisters and to the V.A.D.'s who have helped me in this way, I tender my most grateful thanks. I acknowledge the guidance received from two recent publications—*Surgery of Modern Warfare*, edited by Hamilton Bailey, and *Fractures and other Bone and Joint Injuries*, by R. Watson-Jones.

The exigencies of military service place many obstacles in the way of authorship, but the publishers as before have been most considerate and most patient. My wife, who is my severest critic, has corrected the entire manuscript in proof, and has made many valuable suggestions; without her help this second edition could not have been prepared.

ERIC L. FARQUHARSON.

KIRKWALL, ORKNEY,
September, 1942.

EXTRACT FROM PREFACE TO FIRST EDITION

FOREWORD

MR. FARQUHARSON has a reputation for ingenuity, and it seems to me that this book is a confirmation of that opinion. He has produced a volume which is in certain respects unique. Without entering into operative detail he has collected and described procedures which are of supreme importance to house surgeons and clinical assistants. He has described them so clearly and so fully that there is no room for misconception or doubt, and further, he has given us information on a diversity of subjects such as are rarely brought together within the compass of a single volume. While the book has the merit of individuality (for many of the methods described bear the stamp of Mr. Farquharson's inventive mind), it is in no way parochial or local in its information. Where there are different means of obtaining the same object, they are described, but the whole is presented on a critical and analytical basis, so that the reader is left in no doubt as to the merits of the choices.

Fractures and orthopaedic matters comprise the bulk of the book, and it is appropriate that it should be so. In these departments details are all-important—in fact success or failure often depends upon some point which to the uninitiated may seem of insignificance. Mr. Farquharson appreciates the importance of this, and with a combination of accuracy and simplicity which is altogether admirable, he has given us descriptions of method and technique which should prove most helpful and instructive.

I believe that the book will fill an important place in surgical literature. Its originality will make an appeal, but over and above that it will gain approval for the wealth of its detail and the essentially practical manner in which it is conceived and presented.

One of its outstanding features is the character of the illustrations. A good diagram or photograph can be more informative than a page of textual description, and in this instance the illustrations are so well chosen and so accurate that, though the text is exceedingly clear, they are adjuncts which satisfy questioning and clarify impressions.

Of the making of books there is no end, but there is always room for practical manuals presented with conciseness and originality. It seems to me that *Illustrations of Surgical Treatment* comes into this category, and that therefore it is assured of a welcome by those engaged in surgical pursuits.

John Fraser

EDINBURGH,
October, 1939.

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VERTEBRAL COLUMN AND RIBS

PART I

INFUSION AND TRANSFUSION

I

INTRA-VENOUS SALINE INFUSION

In the early days of intra-venous saline infusion, administration was invariably carried out by the rapid method, whereby a pint or more of solution was allowed to flow into a vein at a relatively fast rate. This method is now advocated only where there has been a *sudden* depletion in the volume of the circulating blood, as occurs in cases of severe haemorrhage and shock. For such conditions, whole blood or plasma is the solution of choice, but where neither of these is available a saline infusion may tide the patient over the stage of acute collapse.

When the loss of fluid or chlorides has been more gradual, as occurs with intestinal obstruction, post-operative vomiting, peritonitis, etc., there may be no demonstrable depletion in the circulating blood, for this can maintain its normal volume and chloride content at the expense of the tissues which become correspondingly dehydrated. In such cases it is manifestly unphysiological to put into the circulation a pint or more of fluid more or less suddenly. Apart from the fact that severe reactions sometimes occur, most of the fluid so suddenly added to the circulation is rapidly excreted by the kidneys, before the dehydrated tissues can benefit to any great extent. Any improvement in the general condition is therefore short-lived, and repeated injections become necessary.

Saline administration in the form of a continuous "drip" has none of these disadvantages. By this method, the total quantity of solution administered together with the rate of flow can be carefully regulated to suit the individual needs of the patient. Once installed, the infusion can be continued for several hours or days, during which time the requirements of the body for fluid, salt and glucose are readily assured, with the minimum of disturbance or physical strain to the patient. In cases of haemorrhage or shock, where an initial improvement has been brought about by a massive infusion, such improvement can be maintained by prolonging the infusion in the form of a continuous "drip."

SOLUTIONS

In most cases intra-venous infusion is employed to combat the depletion of fluid or chlorides in the body, and, as normal saline (0·85 per cent.) adequately meets these requirements, it will usually be the solution of choice. In cases where debility or emaciation is present, and where normal feeding has to be withheld for some time, glucose

may be added in 2½ to 10 per cent. solution. It provides a source of energy in an easily assimilable form, and relieves the tax on the liver glycogen and on the stored fat and protein. "Gum-saline" (normal saline with 6 per cent. gum acacia), owing to its greater viscosity, is eliminated less rapidly from the circulation. It is therefore useful as an emergency measure in cases of haemorrhage and shock, when rapid restoration of blood volume is desired, but for this purpose it is far inferior to whole blood or plasma. Not more than one pint should be given, as reactions to the gum acacia are not uncommon. For the purposes of promoting diuresis, as in cases of anuria, an isotonic (4·28 per cent.) solution of sodium sulphate is advised.

All solutions for intra-venous infusion must be prepared in a laboratory with the strictest aseptic precautions. The water must be doubly distilled and should be freed from pyrogenic substances by treatment with powdered charcoal, or by filtration through a Seitz or other bacterial filter. The purity of the sodium chloride, glucose or other ingredients must be beyond reproach. Many large hospitals, which have adequate laboratory facilities, successfully prepare their own solutions. Smaller hospitals are advised to avoid an onerous responsibility, by utilizing one of several commercial preparations, which are now available at reasonable cost. A wide choice of solutions is provided; these are supplied in sealed flasks, and are guaranteed to be sterile and free from impurities. Of these, the Baxter "Vacoliter" solutions are the best known (see pp. 6 and 7).

APPARATUS AND TECHNIQUE

The method of the "tube and funnel" should now be considered obsolete, as such apparatus is suitable only for a rapid or brief infusion, and it is difficult to observe a strictly aseptic technique. Any apparatus which fulfils modern requirements should be suitable either for a rapid or for a continuous "drip" infusion, and should be designed to prevent any unnecessary exposure of the solution to the air. The essential requirements for a simple and satisfactory apparatus are a sterilizable glass reservoir or container, which is connected to a dropping tube by which the rate of flow can be estimated and adjusted. From this, by means of rubber tubing connected to a needle or cannula, the fluid is run into a vein. The rate of flow is regulated by a screw clip placed on one or other side of (usually above) the dropping tube.

For a rapid infusion, it is essential that the fluid should be heated to approximately body temperature before it is allowed to flow into the circulation. For a continuous "drip" the necessity for heating the fluid is a matter of controversy, but it can hardly be doubted that on general principles it is more satisfactory to administer warmed fluid, if this is possible without complicated apparatus. Nothing

can be gained by warming the solution in the reservoir, as, at the slow rate of infusion generally employed, the warmth is completely dissipated before the vein is reached. The heat in order to be effective must be applied to the fluid immediately before it enters the vein.

A simple apparatus which is equally suitable for a rapid infusion or for a continuous "drip" is illustrated in Fig. 1. The fluid is

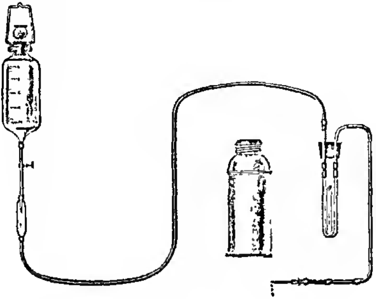


FIGURE 1

The Author's apparatus for Intra-venous Infusion. A sterilizable glass flask of 20 oz. capacity acts as reservoir. This is connected to a glass dropping tube by a short length of rubber tubing on which a screw clip is placed. From here the saline passes through a coiled glass tube which is immersed in a thermos flask of hot water; thereafter by a short length of tubing attached to a needle or straight glass cannula, the fluid is led into a vein.

heated by being led through a coiled glass tube immersed in a thermos flask of hot water. The rubber tubing between this coil and the cannula should be as short as possible, in order to minimize heat loss before the vein is reached. The reservoir is filled up with *cold* saline as often as necessary. At slow rates of flow (*i.e.*, not exceeding one drop per second), the thermos flask should be refilled with *boiling* water every two hours. This ensures the fluid entering the vein at approximately body temperature. With faster rates of flow, the thermos flask is filled with water at a correspondingly lower temperature, and it is refilled at more frequent intervals. For a rapid infusion, the thermos flask is filled with water at about 110° F. (*i.e.*, comfortably hot to the hand).

This apparatus, after being partially disconnected, is boiled or autoclaved before use, with the exception of course of the thermos flask which does not require to be sterile. After being connected

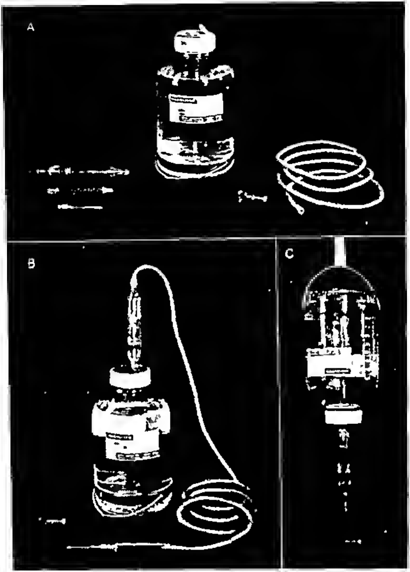


FIGURE 2

"Vacoliter" saline infusion apparatus and method of use.

A.—1000 c.c. flask with delivery apparatus, consisting of dropping tube, 6 ft. of rubber tubing and clip, glass connection and intra-venous needle.

B.—The metal cap is removed and the rubber diaphragm cut away. The dropping tube, which has been connected to the rest of the delivery apparatus, is plugged into one of the two holes in the rubber bung, indicated by an arrow. The other hole carries a glass air inlet tube already fixed in position.

C.—The flask is inverted and suspended by the handle, ready for use.

up, the apparatus should be washed through with pyrogen-free distilled water. The screw clip is closed and the flask filled up with saline solution. The clip is then opened, and the fluid allowed to run through till all air has been expelled from the tubing. The apparatus is now ready for use.

"Vacoliter" solutions are supplied in sealed sterile flasks. Administration of the solution is effectively and simply carried out by means of the delivery apparatus, or "needle assembly set" supplied by the manufacturers. This consists of a special dropping tube, which plugs into a hole provided in the rubber bung of the flask, six feet of rubber tubing with screw clip, an intravenous needle and glass connection. Details of the apparatus and the method of use are shown in Fig. 2. The flasks when empty are returned to the manufacturers, but the needle assembly set is retained for repeated use, being re-sterilized on each occasion. *In an initial order for* "Vacoliters" it is recommended that needle assembly sets should be obtained *in the proportion of one set* to every six flasks. Thereafter, they should be renewed only as required. (Needle assembly sets can be supplied by the manufacturers sterilized and in sealed packets, so that they are ready for immediate use.)

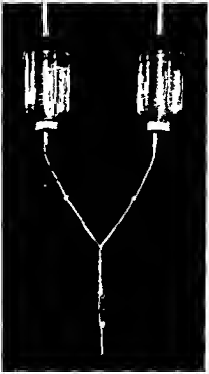


FIGURE 3

Two "Vacoliter" flasks connected up for continuous "drip" infusion.

For continuous "drip" infusion with "Vacoliters," two flasks should be connected as shown in Fig. 3. Before one flask is completely empty, the second is brought into use. The first flask is then replaced. If the necessary connections for installing two flasks at the same time are not available, there is no great difficulty in substituting a new flask for the one in use, but a careful technique should be observed to prevent entry of air into the tubing. *The first flask must not be allowed to empty completely, and while the dropping tube is being changed to the new flask, the screw clip must be closed.*

For a rapid infusion, "Vacoliter" solutions are warmed by immersing the sealed flask in hot water. For a continuous "drip" infusion, heat is applied by a hot-water bottle placed on the rubber tubing close to the vein, or the method of the heating coil and thermos flask (Fig. 1) may be employed.

After the outbreak of War, a simplified and readily transportable apparatus for saline infusion was issued by the Emergency Medical Services (Fig. 4). This consists of a pint bottle with a metal screw top which has two holes punched in it. and which encloses a rubber disc or washer. After the bottle has been filled with saline, the rubber disc and screw cap are loosely applied, and the whole is

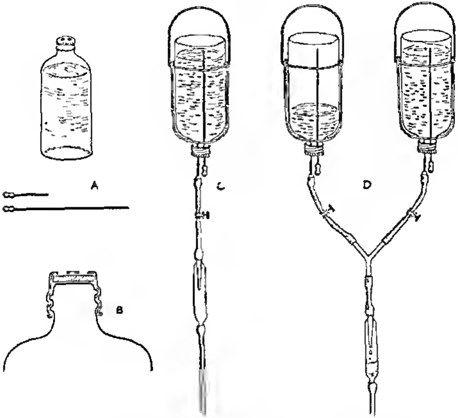


FIGURE 4

Saline infusion apparatus, as issued by the Emergency Medical Services.
A.—Sealed bottle of saline, with needles to act as delivery tube and air inlet.
B.—Method of sealing the bottle by a rubber disc held by a perforated metal cap
C.—Needles *in situ*. Delivery tube connected. Bottle inverted and ready for use.
D.—Two bottles connected up for continuous infusion

sterilized in the autoclave. The bottle is then sealed by tightening the screw cap, so that the contents are stored in a sterilized condition, ready for use. The delivery apparatus is of the simplest. Two large bore needles, one short and one long, are plunged through the parts of the rubber disc exposed by the holes in the metal cap. The short needle forms an outflow tube for the saline; it is connected to a dropping tube and thence to a needle or cannula. The long

needle which reaches to the bottom of the bottle acts as an air inlet. The bottle is inverted and suspended in a wire cradle (Fig. 4 C).

Although this apparatus is designed for rapid infusion, there is no difficulty in using it for a continuous "drip," but, as with the use of "Vacoliters," care must be taken not to allow air to enter the tubing while the bottles are being changed. For a prolonged "drip" infusion, it is more satisfactory to connect up two bottles, as shown in Fig. 4 D. The solution is heated in the manner described for infusion with "Vacoliters."

Many hospitals which prepare their own intra-venous solutions are now issuing them in sealed bottles of this type. Little extra trouble is involved in the preparation. The solution is ready for immediate use, and is administered directly from the bottle without

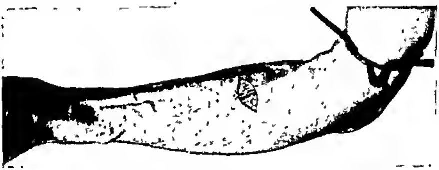


FIGURE 5
The cephalic vein exposed in the radial side of the forearm.

further exposure to the air. No other reservoir is required, and the accessory apparatus is reduced to a minimum.

Choice of vein.—The veins of the cubital fossa are usually utilized for a rapid infusion, but for a continuous "drip" they should be avoided whenever possible, although they present a great temptation when other veins are not easily identified. If the cubital veins are used for a "drip," a splint will be required to keep the elbow at rest. Besides adding to the discomfort of the patient, this interferes with the normal venous return from the arm, and the "drip" will often be found to function imperfectly.

The best results are obtained by utilizing the cephalic vein in the middle or upper third of the radial side of the forearm. Even when the veins generally are collapsed, this vein is usually identifiable, and is of a convenient size for the purpose. Furthermore, since the vein is intermediate between the elbow and wrist joints, the needle or cannula is less likely to be disturbed by movement, and there is no necessity for splinting.

The great saphenous vein is sometimes employed, usually at the point where it lies anterior to the medial malleolus (Fig. 9), but a splint is required to prevent the cannula being dislodged by

movement at the ankle joint. This method is especially useful in children.

In infants, the anterior fontanelle affords access to the superior longitudinal sinus, by which route a continuous "drip" may be administered. A specially designed needle is required.

For a rapid infusion or for a continuous "drip" of short duration, it is often unnecessary to expose the vein. Unless this is very collapsed, an ordinary intra-venous needle can usually be inserted

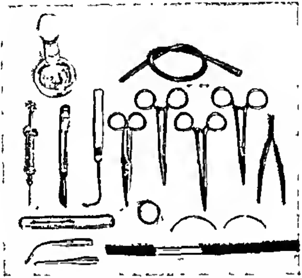


FIGURE 6

Instruments, etc. required for exposure of vein. Venous tourniquet, syringe and local anaesthetic; scalpel, sharp-pointed scissors and aneurysm needle; two or three pairs of fine artery forceps; catgut, glass cannulae; dissecting forceps; skin needles and sutures

without great difficulty. By such means, a continuous "drip" may be carried out for 12 to 24 hours, but constant supervision is required, as thrombosis of the vein and leakage into the tissues are more likely to occur than when a cannula is tied in.

Exposure of the vein.—The instruments required are shown in Fig. 6. When a "drip" infusion is to be employed post-operatively, it should if possible be installed during the major operation, or before the patient leaves the theatre. All the necessary instruments will then be available, no local anaesthetic will be required, and the operator will not have to contend with post-operative restlessness, which is so liable to be encountered if the infusion is delayed till the patient has returned to bed.

In a conscious patient a local anaesthetic is required. This is injected *intradermally* in the line of the proposed skin incision. Care must be taken to avoid puncture of the vein. A transverse incision

across the line of the vein is usually to be preferred (Fig. 5), and is definitely indicated where the vein is not identifiable through the skin. If the vein is visible a half-inch incision is adequate. After the skin is incised, the superficial fascia is cleared by inserting the points of sharp scissors and opening them on each side of the line of the vein (Fig. 7 A). It is often advised that a pair of small artery forceps be used for this purpose, but sharp-pointed scissors will be

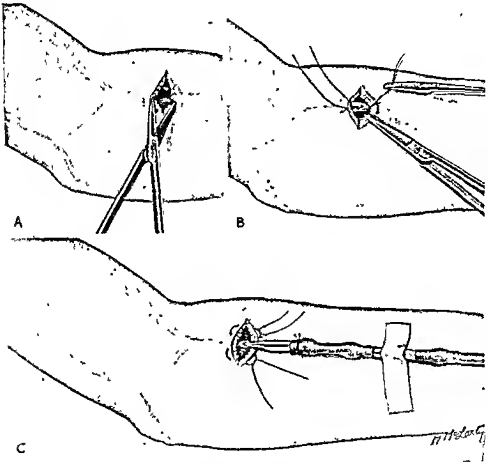


FIGURE 7

Drawing to show the method of exposing the vein, and of tying in the cannula.

found to be much more efficacious, and when reasonable care is used the vein is never damaged. When the vein has been isolated in this way, two ligatures are passed around it: the distal one is tied and held in forceps, the proximal one is half tied in readiness to receive the cannula, and its ends are left loose. (If the tourniquet is removed at this point unnecessary bleeding will be prevented.) With sharp-pointed scissors a nick is made in the vein between the ligatures, the distal one being used as a retractor. The cannula, which should

be free from air bubbles and slowly dripping, is quickly inserted, and the proximal ligature is tied. At this point a stitch should be passed through the skin and tied round the base of the cannula, in order to secure it firmly in position. This is a most valuable precaution, for so often the cannula is accidentally pulled out of the vein before the tubing can be fixed by strapping. The skin wound is closed with two mattress sutures. A piece of strapping is placed over the glass connection, and a light dressing is affixed to the wound. *No splint is applied.* The arm lies alongside the body, loosely anchored by a piece of bandage passed over the wrist and safety-pinned to the sheet (Fig. 8).

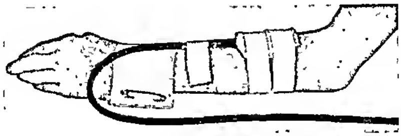


FIGURE 8

The glass connection is strapped to the arm, and a small dressing applied to the wound. The arm is anchored by a strip of bandage passed over the wrist and safety-pinned to the sheet.

The reservoir is suspended three or four feet above the level of the arm, and the thermos flask (Fig. 1) rests on a chair at the bedside.

MAINTENANCE OF A CONTINUOUS "DRIP"

It is essential that the flow of saline should be continuous. If it is stopped for more than a few moments, back flow of blood will occur into the needle or cannula and clotting may result. With the apparatus shown in Fig. 1, the reservoir should never be allowed to empty, and the nurse is instructed to refill it when it becomes less than a quarter full. She should also inspect the rate of flow at periodic intervals, and regulate it according to instructions. The changing of a "Vacoliter" or saline bottle (Figs. 2 and 4) should not be entrusted to a nurse, unless she has shown an understanding of the necessary technique.

Rate of flow.—The rate of flow usually advised for a "drip" infusion is from thirty to forty drops per minute, or four and a half to six pints a day, but this can be varied within wide limits to meet the requirements of the patient. When his fluid or chloride needs are urgent, as in intestinal obstruction or after a severe operation, this rate can be doubled or even trebled for the first two or three

hours, or until a satisfactory improvement is obtained. In cases of collapse due to shock or haemorrhage one or two pints of saline may be run in rapidly (with the clip completely unscrewed), and the volume of the circulation thereafter maintained by continuing the infusion at the slow rate.

Temperature of the fluid.—The methods of heating the solution with the different types of apparatus have already been described. With the apparatus shown in Fig. 1, the thermos flask should be refilled with hot water as required—at the normal slow rate of flow, with *boiling* water every two hours. At faster rates of flow, the thermos flask is filled with water at a correspondingly lower temperature, and it is refilled at more frequent intervals. With other apparatus, the solution can be effectively warmed by the placing of a rubber hot-water bottle on the tubing close to the vein. The temperature of the fluid which is being administered may be estimated by feeling the warmth of the rubber tubing at its attachment to the needle or cannula.

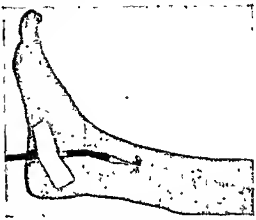


FIGURE 9

Utilization of the saphenous vein above and in front of the medial malleolus.

Duration of the infusion.—In the cases where a satisfactory result is obtained, it is rarely necessary to continue the infusion for longer than 48 hours, and infusions of much shorter duration frequently produce the desired effect. Numerous cases are recorded however where a "drip" infusion has been maintained for several days, with most beneficial results. In the absence of such contra-indications as cardiac and renal failure and pulmonary congestion, the dangers of over-dosage are comparatively slight. Some workers, notably Hamilton Bailey, insist that a "balance sheet" be kept to compare the amount of fluid administered with that lost in the urine and by vomiting. In the making up of such a balance sheet, the quantity of fluid lost by sweating and by respiration must be included; the average loss from these sources is about $1\frac{1}{2}$ pints per day. This precaution however is probably only necessary with infusions continued for more than 48 hours. In the case of a patient who is in urgent need of fluids, and whose powers of assimilation are great, it is obvious that no agreement can be expected between the two sides of the balance sheet.

Removal of the cannula.—It is quite unnecessary to re-open the wound. The cannula is easily withdrawn after the stitch securing

its base has been cut. It is unnecessary even to remove the dressing on the wound.

Complications.—*Stoppage of flow.*—If the flow of saline becomes arrested, *immediate* steps must be taken to restart it. Stoppage is often due to kinking of the tubing, and such a possibility should be investigated. In other cases, the flow may be restarted by rotating the cannula slightly in the vein. More often the obstruction is due to clotting within the cannula, and this can be cleared by milking the rubber tubing towards the vein. The danger of embolism as the result of this procedure has been unnecessarily exaggerated.

FIGURE 10
Method of clearing the dropping tube, if the fluid level rises above the inner tube.

Filling up of the dropping tube.—If this occurs, the falling of the drops from the inner tube will be obscured, and it will be impossible to determine the rate of flow or even its total arrest. To restore the fluid level to the normal, the clip is closed and the dropping tube disconnected *at its upper end.* Unless obstruction is present, the level in the tube will slowly sink. Before the fluid disappears from sight, the tube is reconnected to the rubber tubing above (Fig. 10).

Swelling or redness around the vein.—This may occur after 24 to 48 hours; as a rule it is only encountered when glucose solutions are used, and is due to an irritative phlebitis. Unless the reaction is severe, it can be disregarded, as it usually settles down as soon as the infusion is withdrawn. Leakage of solution into the tissues is rare, but if it occurs another vein must be selected.

Rigors occasionally occur at the commencement of an infusion. They have been thought to be due to impurities in the sodium chloride, or to pyrogenic substances in the water used, but improperly cleaned apparatus must frequently be held at fault. The apparatus must be not only sterile, but *scrupulously clean,* and should be thoroughly washed through with pyrogen-free distilled water before use. Rigors can also be caused if the solution has been allowed to become cold, especially if it is being administered at a fast rate. The rigor is usually of short duration, and yields rapidly to symptomatic treatment. It is rarely necessary to discontinue the infusion, but the rate of flow may be reduced.

II

TRANSFUSION OF BLOOD AND PROTEIN FLUIDS

BEFORE a blood transfusion is attempted, careful precautions must be taken to ensure compatibility between the red blood corpuscles of the prospective donor and the serum of the patient, as incompatibility may give rise to serious and possibly fatal results.

Human bloods are divisible into four groups, of which the Moss classification has hitherto been the most popular in clinical practice. The International classification however is the more satisfactory, in that it demonstrates the manner in which the division affects *both* the serum and the red cells. Agglutinating substances in sera are referred to as *agglutinins*; these are two in number and are designated α and β: in the serum of any individual either of these may be present separately, both may occur together, or neither may be present at all. Thus the different types of sera may be grouped as α, β, $\alpha\beta$, and *O*. The red cells may be similarly classified according to their susceptibility to agglutination (*i.e.* by the presence of *agglutinogens* in their substance). Thus cells which are agglutinated by α serum alone are classified as group A, and cells agglutinated by β serum alone as group B. Cells of group AB are agglutinated by α, β or $\alpha\beta$ serum, while cells which are not agglutinated by any serum are designated as being of group O. By the International classification, the four blood groups are named according to the corpuscular reactions—AB, A, B, and O, corresponding to the Moss grouping of I, II, III, and IV.

Obviously α serum and A red cells cannot exist in the blood of the same individual (or agglutination would occur), and similarly β serum and B cells cannot co-exist. The four possible combinations are indicated by the following table:—

Moss Classification	International Classification	
	Serum	Corpuscles
Group I	O	AB
Group II	β	A
Group III	α	B
Group IV	$\alpha\beta$	O

Among the population of Western Europe and America, the distribution of the blood groups is given as follows (Wright):—group O, 46 per cent.; group A, 42 per cent.; group B, 8 per cent.; group AB, 3 per cent.

For the purposes of a blood transfusion it is only necessary to consider the *cells of the donor* and the *serum of the recipient.* If incompatible blood is administered, the injected red cells will be immediately agglutinated and later haemolysed by the serum of the host. The action of the donor's serum on the patient's corpuscles can be disregarded, as the transfused serum is so rapidly diluted by the patient's serum that its agglutinating powers are lost.

Individuals whose blood belongs to group AB, having no agglutinins in their serum, have been called "universal recipients." Similarly individuals of group O, whose red cells cannot normally be agglutinated, have been called "universal donors." Such designations are not entirely satisfactory, as owing to the presence of unclassifiable sub-groups about which little is known, agglutination may sometimes occur unexpectedly, and except in cases of emergency, it is not justifiable to carry out a transfusion without a direct compatibility test (*vide infra*).

COMPATIBILITY TESTS

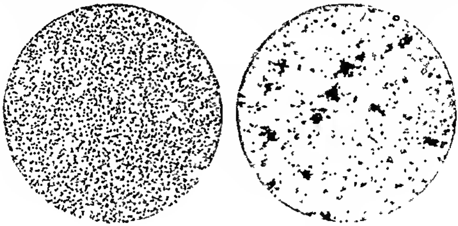
Two distinct types of test are commonly employed—the indirect test or "grouping," and the direct or individual compatibility test.

The indirect test.—This test is necessary when it is desired to obtain the services of a voluntary donor from a blood transfusion service, or when stored blood is to be requisitioned from a blood bank. The group to which the patient's blood belongs is ascertained by the method about to be described, and a donor or blood of the same group is then asked for.

For the purposes of this test it is necessary to have stock sera of groups A and B, which are supplied by most firms of manufacturing chemists. The agglutinating powers of these sera on the cells of the blood sample are investigated.

The microscopic method is to be preferred. A drop of each serum is ejected on to a microscope slide, and the drops are labelled A and B. The blood to be tested is obtained from a prick on the nail fold or lobule of the ear. It is usually advised that the blood should be diluted for the purpose of the test; this is convenient when a number of samples are to be tested, as in laboratory work, but it is quite unnecessary when making an individual test. Without dilution, however, it is essential that only an infinitesimal quantity of blood should be used, as there must always be an excess of serum, as compared with the corpuscles under test. *As much as can be carried on the needle point* is more than adequate; this is mixed with the drop of group A serum. After cleansing the needle, a similar quantity of blood is mixed with the drop of group B serum. The occurrence of agglutination is then investigated under the low power of a microscope. Micro-photographs of such a test are shown in Fig. 11. If agglutination is going to take place, it will usually be seen to com-

mence within two minutes, but some workers insist on a period of fifteen minutes being allowed to elapse before the possibility of its



A B

FIGURE 11

Compatibility test—microscopic appearances.
No agglutination with group A serum. Commencing agglutination with group B serum. This blood therefore belongs to group A.

occurrence is denied. Agglutination will be hastened by warming and by gently rocking the slide.

The naked-eye method can be relied upon when a microscope is not available. Rather larger quantities of blood are mixed with the stock sera, but excess must be avoided. As much as will lie on the end of a glass rod will give a satisfactory test. After a few minutes the slide is examined obliquely against the light. Agglutination is apparent if the diffuse redness of the drop becomes patchy or granular; the appearances have been likened to those of cayenne pepper or brick dust. A white china plate may be used with advantage instead of a microscope slide. The appearances of agglutination on naked-eye examination are shown in Fig. 12.

No Agglutination Agglutination

FIGURE 12

Compatibility test—naked-eye appearances.
(*By courtesy of Messrs. John Wright & Son, Bristol.*)

The group to which the sample of blood belongs is determined as follows :—

Agglutination with both sera	Group AB.
Agglutination with group B serum alone . .	Group A.
Agglutination with group A serum alone . .	Group B.
Agglutination with neither serum	Group O.

It should be emphasized that two bloods which have been shown by the indirect test to be of the same group are not invariably compatible for the purposes of transfusion, and, except in cases of extreme urgency, it is advisable to carry out the direct test as an additional precaution.

When the services of a voluntary donor are to be obtained, or when stored blood is to be requisitioned from a blood bank, it is always advisable that the patient's blood should be grouped beforehand. It is the work of only a few minutes to perform the necessary test, and only in cases of emergency and where stock sera are not available, is it justifiable to ask for a "universal" donor or for group O stored blood. In cases where such a donor or stored blood of this group has been obtained, and the patient's blood has not been typed, it is particularly necessary that the individual compatibility should be confirmed by a direct test.

The direct test.—By this method no attempt is made to group

FIGURE 13

Withdrawal of blood into capillary tube On right, separation of serum after the tube has been centrifuged.

the blood of the patient, but his blood is tested directly against that of the prospective donor. Properly carried out, the test is thoroughly reliable, and is the method of choice when a prospective donor or choice of donors is at hand. The direct test is also advised as a precautionary measure, even although the bloods have been shown to be of the same group. For the reasons already stated, it is necessary to test the *serum* of the recipient against the *corpuscles* of the donor. Mere mixing of the two bloods on a microscope slide is quite useless, because, if agglutination occurs, it is impossible to determine whether this affects the cells of the donor, of the recipient, or of both, and incompatibility between the cells of the patient and the serum of the donor is no bar to a successful transfusion. Furthermore, whole blood is too thick an emulsion for the satisfactory investigation of agglutination, and dilution of the blood with saline or citrate solution will diminish the agglutinating powers of the serum.

The first essential therefore is to obtain a small quantity of the patient's *serum*. This is done by allowing a sample of blood to clot. It is unnecessary to obtain a syringeful of blood; two drops of blood from a finger or ear prick are adequate if the blood be drawn into a capillary tube (Fig. 13). When clotting has occurred, a little of the residual clear serum is transferred to a microscope slide. The test will be found to be much more satisfactory, if time can be allowed for absolutely clear serum to be obtained. The separation of the serum can be greatly accelerated by centrifuging the capillary tube, the ends of which have been sealed in a flame. If a capillary tube is not available, a small glass tube of the type used for dispensing hypodermic tablets may be substituted. The remainder of the test follows the lines of the indirect test. A minute quantity of whole blood from the donor is mixed with the serum, and the occurrence of agglutination is investigated as already described, either by the *microscopic* or *naked-eye methods*.

TRANSFUSION OF FRESH BLOOD

Considerable advances in the technique of collecting and administering blood followed the outbreak of war, when blood transfusion services were organized in all parts of Britain. The citrate method of preventing clotting of the blood during its collection and administration has entirely replaced other procedures occasionally advocated. It is simply carried out, and does not require any specialized apparatus. The older practice of withdrawing the blood into an open pint measure, and the time-honoured method of administration by tube and funnel have both been discarded, as they involve unnecessary exposure of the blood to the air, with consequent risk of contamination from this and other causes.

Apparatus required.—For collection of the blood, a narrow-necked bottle or flask should be used. The type of bottle commonly issued by the Emergency Medical Services, and by the Army Supply Depot, is shown in the accompanying illustrations. Any bottle of suitable size however can be used. If a handle for suspension is not attached, a wire cradle should be provided or improvised. The blood is led through rubber tubing directly into the bottle, and is administered therefrom to the patient, so that the risk of contamination is greatly reduced.

The blood is allowed to flow into a solution of sodium citrate contained in the bottle. Various quantities and concentrations of this solution are advised, but the final concentration in the collected blood should be at least 0·3 per cent. This necessitates the addition of 1·75 gm. of citrate per pint (570 c.c.) of blood: 50 to 75 c.c. of 3·5 per cent. solution is a convenient quantity and concentration.

Some transfusion services issue sealed bottles containing the

citrate solution, sterilized and ready for use, and hospital laboratories are following this example. Alternatively the bottle containing citrate

FIGURE 14

Instruments and apparatus required for collection of blood from a donor. The bottle is of the type issued by the Emergency Medical Services, and by the Army Supply Depot. The rubber cork is fitted with two glass tubes, one of which is connected by rubber tubing, interrupted by a second glass connection, to an intravenous needle. Sodium citrate solution, local anaesthetic, two syringes, and a fine bladed scalpel or tenotomy knife complete the armamentarium.

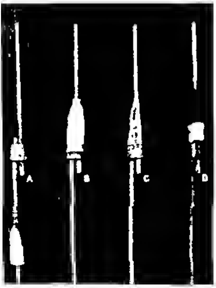


FIGURE 15

Different types of filter for blood transfusion

A.—Gas mantle filter in special glass container.
B.—Gas mantle filter attached to cork of bottle.
C.—Stainless steel gauze filter similarly attached.
D.—Improvised filter, made by winding 2 feet of 1-inch ribbon gauze round air inlet tube.

can be autoclaved before use, or the two may be sterilized independently.

A large-bore intra-venous needle with a suitable length of rubber tubing is used for the withdrawal of blood into the bottle. The

incorporation of a glass connection close to the needle is a useful adjunct. The tubing is attached to one of two short glass tubes passing through a rubber cork. The other tube acts as an air outlet to the bottle during the collection of blood. This apparatus together with the few simple instruments required is illustrated in Fig. 14.

The blood should be administered whenever possible directly from the bottle into which it has been collected. A second rubber cork is required for administration of the blood; this also carries two tubes, but one must reach to the bottom of the bottle to act as an air inlet when the bottle is inverted. The inclusion of a dropping tube and screw clip in the delivery tubing allows estimation and adjustment of the rate of flow.

FIGURE 16

Filtration by glass beads.

Filtration.—Some form of filtration of the blood is advisable, as small clots frequently form during collection, and these are liable to block the needle or cannula. Several different types of filter are in use. "Gas-mantle" filters and filters made of stainless steel gauze are illustrated in Fig. 15; the latter are readily cleaned and can be used repeatedly. If no ready-made filter is available, an efficient substitute can be improvised by the method shown in Fig. 15 D. Glass beads (Fig. 16) or stainless steel ball-bearings also constitute an effective filter; they are usually placed in the bottle and are sterilized with it in the autoclave, before the blood is withdrawn.

Two types of blood transfusion apparatus issued by the Baxter Laboratories are illustrated in the Appendix, Plates 62 and 63, where the methods of use are also described.

Withdrawal of the blood.—If the veins of the donor are not very prominent, they may be made to stand out if the donor will soak his arm in very hot water for a few minutes. The donor lies on an operating table with his arm at his side or abducted with the hand resting on a small table. A sphygmomanometer armlet inflated to 60 mm. should be used as a tourniquet. If this is not available a rubber catheter is an effective substitute, but care must be taken that it is not applied so tightly as to impede the arterial flow. The skin is sterilized with ether or spirit; iodine is avoided as it tends to obscure the veins. Some citrate solution is run through the rubber tubing and needle (Fig. 17), to prevent clotting of the blood. The citrate is retained in the tubing and needle, if the tubing is clamped with a spring clip before the syringe is detached (Hamilton Bailey). Any suitable vein in the cubital region is selected, and a small injection of local anaesthetic is made *intra-dermally* over the vein, so that a wheal is raised, causing immediate insensitivity of the skin. Subcutaneous infiltration should be avoided as it obscures the outline of the vein. The insertion of the needle into the vein is greatly

facilitated if a small nick is made in the skin with a fine-bladed tenotomy knife. The needle is now inserted *slowly and steadily* into

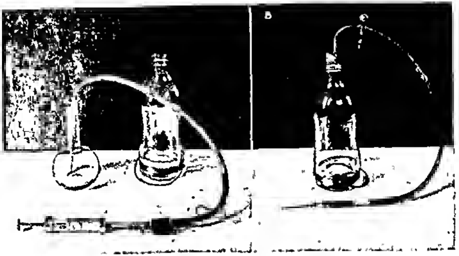


FIGURE 17

A.—The rubber tubing and needle are washed through with citrate solution in the manner shown While the syringe is still attached, the rubber tubing is clipped, so that the citrate is retained therein.
B.—The apparatus ready for withdrawal of blood The requisite amount of citrate solution has been placed in the bottle When the vein has been entered, the clip is released.

the vein, which is usually entered without difficulty. If the previous nicking of the skin is omitted, the needle is very apt to pass through

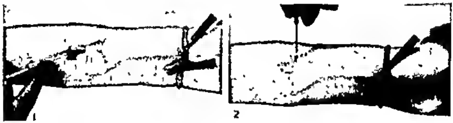


FIGURE 18

1 Injection of local anaesthetic into the skin over the vein; a small wheal is raised.
2. The skin over the vein is nicked with a fine tenotomy knife.

with a jerk, pushing the vein aside or puncturing it on its deep aspect. Many promising veins are ruined in this way. Successful insertion of the needle into the vein is apparent from the appearance of blood in the glass window. As soon as this is accomplished, the spring clip is released; blood should then flow steadily through the tubing into the bottle, which is gently swirled by an assistant to ensure thorough mixing of the blood and citrate. The donor opens and closes his hand rhythmically throughout the collection. It is usually necessary for the operator to steady the needle in position at an

angle which allows the maximum flow. After a varying time, the rate of flow may be found to diminish. It can often be re-established by altering the angle of the needle, or by withdrawing it slightly; adjustment of the pressure exerted by the tourniquet may also have the desired effect. If the needle slips out of the vein, it is rarely possible to re-insert it, and another vein should be utilized. No special virtue is attached to keeping the blood warm during its

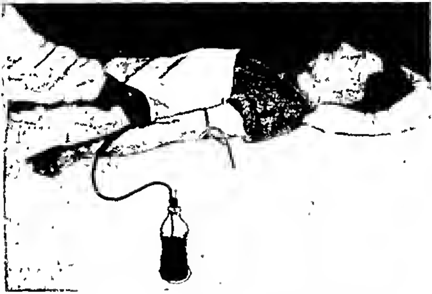


FIGURE 19

Withdrawal of blood into the bottle. The surgeon steadies the needle in the vein, while an assistant should gently swirl the bottle to ensure thorough mixing of the blood and citrate. The donor opens and closes his hand rhythmically during the collection.

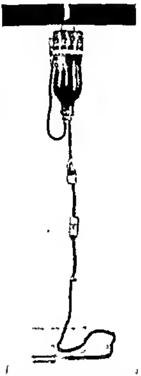
collection; it is simpler to re-warm it just before its administration to the patient. It is not advisable to take more than a pint of blood at one time from an individual donor.

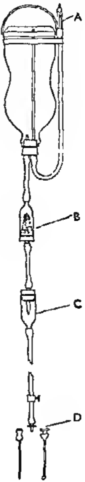
Administration of the blood.—As already stated, the blood is administered directly from the bottle into which it has been collected. The delivery apparatus and the different types of filter have been described. The apparatus issued by the Emergency Medical Services, and by the Army Supply Depot, is illustrated in Figs. 20 and 21.

In many cases it may be possible to administer the blood by intra-venous puncture, but where the veins are too collapsed for successful insertion of the needle, or when the flow is found to be unsatisfactory, it will be necessary to tie in a cannula. A vein is exposed in the arm in the manner described for saline infusion, but here there is not the same objection to using a vein at the bend of the elbow, unless a prolonged "drip" transfusion is intended. In a collapsed patient, the small calibre of the veins may render the

gravity method somewhat tedious; positive pressure may then be applied to the air inlet tube of the bottle, but this is not very often required.

An alternative apparatus for administering the blood is illustrated in Figs. 22 and 23. The blood is collected into a conical flask





FIGURES 20 AND 21

Apparatus for administration of blood.
(*Emergency Medical Services and Army Supply Depot.*)
A.—Air inlet tube with non-return valve.
B.—Gas-mantle filter in glass container.
C.—Dropping tube.
D.—Needle and cannula.

and is administered under positive pressure supplied by a hand pump. Great care must be taken that air does not enter the vein when the flask is emptied of blood. As soon as air bubbles begin to ascend in the glass tube, the rubber tubing is pinched and the pressure is relieved by lifting the cork or opening the valve.

Volume and rate of transfusion.—The amount of blood to be administered is determined by clinical impressions, which should be supported by serial blood pressure readings. These latter serve as a guide to the sufficiency of the transfusion, and prevent overloading of the circulation. One pint of blood is the usual amount for a

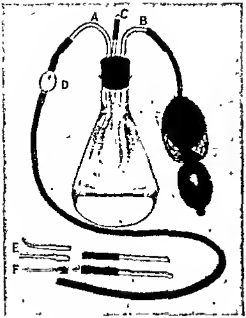


Figure 22

Special flask (Robertson's—modified) *for administration of blood.* Tube A extends to the bottom of the flask, at the angle between side and base. Tube B extends just below the cork. The short tube C has a hole at the side which is covered with rubber tubing; it functions as a valve by which the pressure inside the flask can be reduced, if the flow of blood is too rapid. The glass dropping tube (D) shows the rate of flow. E and F—curved and straight glass cannulae and intra-venous needle, with suitable fittings

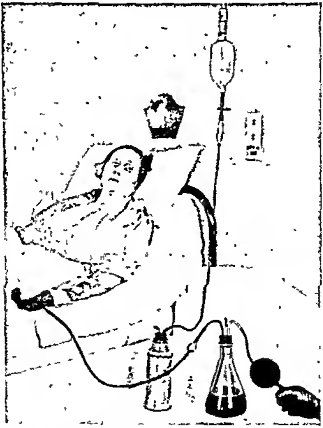


Figure 23

Administration of the blood. A continuous saline "drip" had previously been installed, and this was temporarily discontinued to allow the blood to be given. The tubing leaving the thermos flask has been disconnected, and is attached to the flask containing the blood.

massive transfusion, but up to two pints may be required in patients suffering from severe shock or haemorrhage. It should be noted, however, that the most urgent need of such patients is for fluids rather than for red cells (see p. 30), and unless very severe haemorrhage has occurred, it is better to give a combined transfusion of blood and plasma or serum, rather than to overload the circulation with unwanted red cells.

It is usually advised that the blood should be given slowly, at the rate of a pint in twenty to thirty minutes, but in severely shocked patients, more rapid administration is called for. It is considered safe to administer up to two pints *quickly* in patients whose systolic blood pressure has failed to recover to 100 mm. with the simple measures of rest and warmth.

In young children the quantity of blood which can be safely transfused is relatively small. For infants the amount given should not exceed 15 c.c. per lb. body weight. As in the case of continuous saline infusion, the saphenous is likely to be the vein of choice, but in young infants the injection may be made into the superior longitudinal sinus through the anterior fontanelle.

TRANSFUSION OF STORED BLOOD

A description of the methods of collecting and preserving blood for storage is outwith the scope of this book, but certain considerations which arise in regard to its administration will be discussed.

State of preservation.—The blood separates on storage into a corpuscular layer which sinks to the bottom of the bottle, and a layer of supernatant plasma which shows as a clear amber-coloured solution (Fig. 24). Stored blood of good quality shows a sharp line of demarcation between these layers. After a varying period of storage, the fragility of the red cells increases, and partial haemolysis occurs, with diffusion of the corpuscular pigment upwards into the plasma layer. *Fourteen to twenty-one days* is regarded as the safe limit of storage, but if there is evidence of extensive haemolysis within this period, the blood is considered to be unfit for administration. A zone of *haemolytic discoloration extending more than half way up the plasma* layer is incompatible with safe administration. Small clots in the blood do not render it unfit for use, as these will be removed by filtration. Turbidity of the plasma suggests the presence of bacterial infection, and demands that the blood be discarded.

Compatibility.—The blood banks, which were instituted to meet the emergencies of warfare, carry a proportionately larger store of group O blood. Except in such emergencies, however, it is not justifiable to ask for group O blood, without having ascertained the type to which the patient's blood belongs. The patient should normally be typed, and blood of the same group obtained.

The additional precaution of a direct compatibility test is particularly advised *in all cases where stored blood is used. In addition* to the risks already described which occur by the omission of this test, there is *an inevitable possibility of a clerical error in the group* designation of the stored blood. To enable the test to be made

FIGURE 24
Bottle of preserved blood, showing separation into corpuscular and plasma layers, with narrow intermediate zone of partial haemolysis.

without opening the sealed bottle, many blood banks supply a small sample tube containing a specimen of the same blood. The test is carried out as described on page 18.

In grave emergencies, a direct compatibility test is dispensed with, and fortunately accidents are rare. In the absence of such emergency, however, the risk is an unjustifiable one.

Administration.—Preserved blood is stored in a refrigerator at a temperature of 2° to 6° C. It is usually advised that the blood be warmed to body temperature before use, by immersing the bottle in a basin of water at about 37° C. (*i.e. comfortably warm* to the hand). If time is available, however, it is often preferable to allow the blood to warm up itself to room temperature, at which its administration is quite satisfactory. Sudden changes of temperature tend to increase the red cell fragility, and on no account must the blood be immersed in water of a higher temperature than that given above.

Most blood banks supply not only bottled blood, but also the accessory delivery apparatus, sterilized and ready for use. *Filtration is essential* to remove clots formed during storage. Some type of filter will be included in the apparatus provided (Figs. 20 and 21).

REACTIONS TO BLOOD TRANSFUSION

Widely varying figures are given for the proportion of reactions which occur after blood transfusion. Recent researches have shown that reactions are more common when stored blood is used, and that the proportion of such reactions increases with the duration of storage.

Reactions may be classified as non-haemolytic and haemolytic.

Non-haemolytic reactions are also referred to as "anaphylactic" or "common febrile" (Hamilton Bailey). They occur with relative frequency but fortunately are rarely severe. They are believed to be due to an abnormal sensitization to the proteins of the transfused blood, so that they are more common in individuals who suffer from one of the allergic diseases, and in those who may have been sensitized by a previous transfusion. Imperfectly cleaned apparatus, containing fragments of old blood clot, and pyrogenic substances in the water used to prepare the citrate solution, have also been held responsible.

Manifestations occur almost immediately after the commencement of the infusion, i.e. they may appear after only a few cubic centimetres have been given. The patient becomes restless, and complains of tingling pains all over the body, and often of an oppressive feeling in the chest. Flushing of the face with cyanosis is noted, and later, urticaria may appear. Respiration may be laboured owing to bronchial spasm, and vomiting frequently occurs. There is usually an accompanying febrile reaction, when the temperature may rise to 103° or 104° F.

Haemolytic reactions are uncommon, but are liable to be severe, and occasional fatalities have occurred. As the name implies, they result from partial or complete haemolysis of the red cells transfused. They will usually be found to be due to faulty blood grouping, or to the neglect to carry out the additional precaution of a direct compatibility test. They may also occur after the transfusion of old stored blood, containing much free pigment or large numbers of fragile corpuscles.

The *immediate* symptoms are very similar to those described for non-haemolytic reactions, but the additional complaint of *severe pain in the lumbar region is most suggestive of haemolysis, and demands that the infusion should be stopped forthwith,* as there is a danger of sudden collapse and death, if the administration of incompatible blood is continued.

The late reaction usually appears within a few hours of the immediate reaction. It is ushered in by jaundice and haemoglobinuria, resulting from massive haemolysis of the donor's corpuscles. Its severity therefore is likely to be directly proportional to the amount of incompatible blood transfused. Signs of renal insufficiency may occur from blockage of the renal tubules with a pigment of the

haematin order. Complete anuria may result, and, if unrelieved, will cause death from uraemia.

Treatment.—*Prevention* of all types of reaction after blood transfusion can be summarized in the following precautions :—

(1) Careful cleansing of the apparatus, which must be not only sterile, but *scrupulously clean.*
(2) The use of pyrogen-free distilled water for the preparation of citrate and other solutions, and for washing through the apparatus.
(3) Careful grouping of the bloods.
(4) The performance of a direct compatibility test.
(5) The avoidance of over-age stored blood.

Immediate reactions may be due to nothing more than too rapid administration of the blood, and the patient's distress may be completely relieved by reduction in the rate of transfusion. If symptoms continue, the transfusion must at once be discontinued. Rigors, vomiting, etc., are treated symptomatically. For the allergic manifestations, adrenaline has a specific action, and this drug should always be available when a transfusion is being carried out. It may be administered subcutaneously in dosage up to 2 c.c. (Hamilton Bailey).

Late reactions should be treated by massive alkalinization of the urine, as the haematin pigment tends to be precipitated in an acid medium. In addition large quantities of fluid should be given, to promote diuresis. The following procedure is recommended :—* 8 gm. (120 gr.) sodium citrate should be given immediately, and a further 35 gm. (525 gr.) dissolved in 2000 c.c. of suitably flavoured water should be administered during each 24 hours, until the urine is free from pigment. As an alternative to the oral route, 150 c.c. of 3 per cent. sodium citrate solution may be given intra-venously by syringe. This is followed by an intra-venous " drip " of solution containing 3 per cent. sodium citrate and 5 per cent. glucose : 2000 c.c. are administered during each period of 24 hours, until the urine is clear. Hamilton Bailey sounds a warning against the intra-venous administration of such large quantities of fluid to a patient whose renal function may be seriously impaired. Oral administration is therefore to be preferred in cases where it is possible for this to be carried out. The patient should be catheterized at six-hourly intervals, so that the state of urinary secretion can be assessed.

TRANSFUSION OF PLASMA AND SERUM

It has been shown that, in the common surgical emergencies of shock and haemorrhage, the administration of plasma or serum is

* War Office publication.

quite as effective as that of whole blood. Indeed in these conditions, such transfusions have certain definite advantages.

The main danger of both shock and haemorrhage lies in the loss, not of red cells but of fluids. In shock there is a marked reduction in the volume of the circulating blood as the result of capillary exudation, but, in the absence of haemorrhage, there is no obvious loss of red cells. An actual *concentration* in the cellular content of the blood is produced, leading to increased viscosity and further embarrassment of the circulation. This haemo-concentration is found also in cases of haemorrhage, where, owing to the concomitant degree of shock present, the fluid loss is relatively greater than the red cell depletion.

The greatest need therefore of the patient suffering from shock or haemorrhage is for fluids rather than for whole blood, the corpuscles of which would be an additional burden to the circulation. Plasma or serum is ideal for transfusion in these cases. Both fluids are vastly superior to saline solution, for, by virtue of their protein content and the consequent osmotic pressure exerted, they not only restore, but also *maintain* the volume of the circulation. Even in very severe haemorrhage, the most *urgent* needs of the patient can be met by such a transfusion, although administration of whole blood may be called for later to replace the red cells lost. Plasma or serum is particularly suitable for the treatment of shock associated with burns, in which there is additional fluid loss from exudation into the burned area.

Plasma and serum have further advantages over whole blood in that they can be stored safely over a much longer period of time (the dried products will keep indefinitely), they can be transported over long distances, and can be transfused without typing or cross-agglutination tests.

Fluid plasma.—Plasma is usually prepared at the present time from over-age preserved blood in the blood banks, in which case it has been diluted with sodium citrate solution. Blood of different groups is pooled so that agglutinins are absorbed. The plasma is then separated from the corpuscles by siphonage or simple filtration; it is clarified of fat and passed through a bacterial filter, before being bottled ready for use. A pint of blood yields rather less than half this quantity of plasma, and it therefore requires the contribution of two or three donors to make up a pint of plasma.

Citrated plasma in good condition is a clear golden or slightly amber-coloured fluid. Uniform turbidity of the plasma suggests bacterial contamination, and while it may result from a harmless cause, namely incomplete removal of fat, it is safer to discard the plasma as unfit for use. After a varying time the fibrinogen gradually precipitates out in the form of fibrin threads, which coalesce to form larger clots. Provided that the surrounding plasma is clear, such

clots do not prohibit use, as they can be removed by filtration. Plasma should be stored *at room temperature in the dark*, and under these conditions will keep for several months. Refrigeration is not only unnecessary but actually increases the formation of clots.

Delivery apparatus for the administration of plasma is supplied by the depots from which the issue is made. It includes a filter,

FIGURE 25

Bottled plasma (*Army Supply Depot*). Delivery apparatus (supplied sterilized in tin box) is similar to that shown in Figure 21, but the delivery tube and air-inlet tube are of metal instead of glass; these are plunged through the existing cork of the bottle.

and is very similar to, or identical with, that used for administering stored blood. The apparatus issued by the Army Supply Depot is illustrated in Fig. 25.

The volume and rate of the transfusion are governed by the same factors as in the case of whole blood (p. 24). In a severely shocked patient, two pints may be given *quickly*, provided that no reaction occurs. Thereafter its administration may be continued as a slow " drip," and where necessary may be combined with that of whole blood (p. 33). It should be noted that plasma derived exclusively from group O blood contains both α and β agglutinins, and when administered in large quantities is liable to cause agglutination of the red cells in patients of other groups. This danger, however, is probably theoretical rather than real, as the transfused serum is rapidly diluted by the serum of the patient, so that its agglutinating powers are lost. When the plasma is prepared from " pooled " blood the danger does not arise.

Fluid serum.—It has already been stated that when citrated plasma has been stored for some time, the fibrinogen gradually precipitates out in the form of fibrin threads. After these have been removed by filtration, *serum* diluted with sodium citrate remains. The question arises therefore as to whether serum rather than plasma should be prepared in the first instance. It is technically easier to prepare in a sterile filtered state, and it can be stored indefinitely, retaining its clear condition. The absence of fibrinogen in serum can

be disregarded, as the amount of this protein present in plasma plays an insignificant part in the production of osmotic pressure, and in any case much of it may have been lost by precipitation before the plasma is administered. When serum is prepared from freshly drawn blood, no citrate solution is added, so that the protein content is not reduced by dilution.

The relative merits of plasma and serum are a matter of controversy, but the consensus of opinion at the time of writing is that

FIGURE 26

Dried serum (50 gm.) issued in sealed pint bottle (*Army Supply Depot*). Fluid serum is reconstituted by filling the bottle up to the mark with pyrogen free distilled water.

they are equally efficacious. There is, however, some evidence to show that there is a higher incidence of reactions when serum is used.

Dried plasma and serum.—Plasma and serum can be dried, to form a yellowish crystalline powder, which contains all the protein elements of the original fluid. The process is a complicated one, as drying has to be carried out in a vacuum and from the frozen state, in order to avoid denaturation of the proteins. Serum is easier to dry than plasma owing to the tendency of plasma to clot during concentration. One pint of serum yields about 50 gm. of the dried product: this is issued in sealed bottles or ampoules, and *can be stored indefinitely*. It can be transported to another climate at any time and at any distance from the original donor.

Serum is reconstituted by adding to the dried powder the requisite amount of sterile pyrogen-free distilled water. The resulting fluid is slightly turbid, but this is normal and does not prohibit use. Once reconstituted, serum should be used without delay, owing to the dangers of bacterial contamination.

Concentrated Serum.—Dried serum is sometimes reconstituted at

double or even quadruple strength. It has been claimed that concentrated serum is more effective in building up the circulation, in that it reverses the loss of fluid into the tissue spaces, thus correcting the abnormal changes of surgical shock. It appears, however, that the incidence of reactions is higher when concentrated serum is used.

CONTINUOUS "DRIP" TRANSFUSION

It has already been stated that, except in severely shocked patients, all transfusions should be given slowly, at the rate of a fast

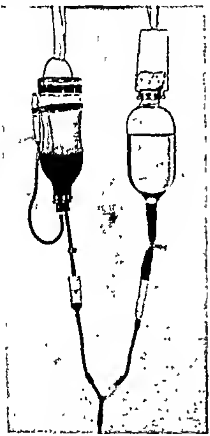


FIGURE 27

A combined "drip" transfusion of blood and saline solution. The blood is filtered by the method shown Fig. 15 D.

FIGURE 28

A combined "drip" transfusion of blood and plasma. By this arrangement the one filter serves both fluids.

"drip"—twenty to thirty minutes being taken for the administration of one pint. When desired, large quantities may be transfused more slowly over a prolonged period. It is then an excellent practice to combine the administration of whole blood with that of saline solution or plasma. Flasks containing the respective solutions should be connected as shown in Figs. 27 to 29, and the two solutions can then be

administered either alternatively or concurrently. For the reasons already given, the surgical patient has usually a relatively greater need for fluids than for red cells, and it is preferable to employ such combinations rather than to administer whole blood throughout. Furthermore,

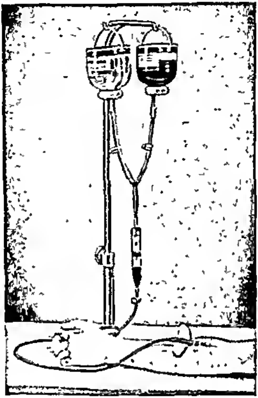


FIGURE 29
A "Vacoliter" and "Transfuso-Vac" combined for transfusion of saline solution and blood
(See pp. 6 and 385.)

special apparatus is required for the continuous administration of whole blood, as provision must be made for oxygen to be bubbled through the blood to prevent sedimentation of the corpuscles.

PART II

VERTEBRAL COLUMN AND RIBS

III

FRACTURES AND DISLOCATIONS OF THE SPINE

COMPRESSION FRACTURES

COMPRESSION fractures are most commonly found in the thoracic and lumbar regions of the spine. The integrity of the vertebral canal is usually preserved, and damage to the spinal cord is comparatively rare.

The treatment consists essentially in the reduction of the wedge-shaped deformity of the bodies of the one or more vertebrae which may be affected, followed by immobilization of the spine in an accurately fitting plaster cast. The deformity, which has almost invariably been caused by some type of flexion injury, can only be corrected by hyper-extension, when the increased tension on the anterior longitudinal ligament, which has its strongest attachments to the upper and lower lips of the vertebral bodies, causes these lips to be pulled apart, so that the normal contour of the body is restored.

In the absence of signs of cord involvement, it is as well to delay active treatment for two or three days. During this time the patient

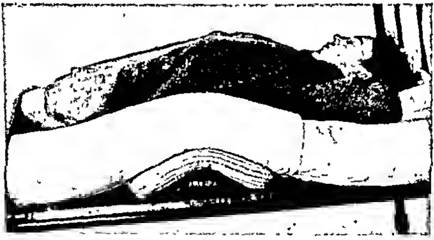


FIGURE 30

"*Hyper-extension mattress*" A long sandbag covered by a bolster has been laid transversely under the mattress. The wire spring is covered with fracture boards. The head of the bed is raised.

is laid on a " hyper-extension mattress " in order that further collapse of a damaged vertebra may be prevented, and in the hope that some degree at least of spontaneous reduction may occur. Such an arrangement is illustrated in Fig. 30. An air mattress or mattress of "*Dunlopillow*" type is arched over a sandbag and bolster or over a rolled-up

blanket placed transversely across the bed, the wire springs being covered with fracture boards. The patient usually tends to slide headwards, so this end of the bed should be raised; a block may also be placed against the feet. The mere placing of a pillow under the back is most unsatisfactory. This invariably slides out of position, and is very liable to cause pressure sores.

It is advisable that the bowels should be well cleared out before the plaster fixation is undertaken, as in the first few days of hyper-

FIGURE 31

Method of decompressing a fracture in the lower thoracic region, by forcible hyper extension (Davis.) *The patient is placed so that the edge of the table is opposite the highest uninjured vertebra below the fracture.*

This method is reserved exclusively for uncomplicated compression fractures. It is contra indicated in fracture-dislocation, and in any case where fracture of the posterior part of the body or of the neural arch is suspected.

extension, paralytic distension of the bowel may be a troublesome complication.

Methods of reduction.—If the deformity is severe, and especially if it is in the thoracic region, the employment of a considerable amount of force may be required before the normal contour of the affected vertebra is restored. When the deformity is less marked, forcible manipulation is unnecessary, as reduction can usually be effected by a degree of hyper-extension, which is within normal limits, and which can be produced by the weight of the body alone, if this is properly applied and controlled.

Forcible hyper-extension.—The method of forcible reduction suggested by Davis is illustrated in Fig. 31. The patient is pulled over the end of an operating-table until the *highest uninjured vertebra below the fracture* is opposite the edge of the table, which is protected by the customary thin sponge mattress. The spine is then

forcibly hyper-extended, while an assistant holds down the pelvis, and at the same time prevents the patient from sliding headwards. The necessary fulcrum for this leverage is provided by the inter-articular joints, which in uncomplicated compression fractures are

FIGURE 32

Reduction of a compression fracture in the lumbar region by the method of Watson Jones. The felt jacket and the partially finished plaster cast are shown. The felt has still to be turned over the edges of the cast. *Note the lordosis obtained in the lumbar region.*

always intact. Considerable force may safely be applied, as the immensely strong anterior longitudinal ligament acts as a limiting membrane preventing excessive hyper-extension. In cases of fracture-dislocation or fracture involving the posterior part of a vertebra, forcible hyper-extension is dangerous and must on no account be attempted. After such forcible reduction has been carried out, the patient is

placed in one of the two positions about to be described, and a plaster cast is applied.

Method of Watson Jones.—No special apparatus is required. The patient is laid in the prone position between two tables of different heights, or between a table and bed (Fig. 32). The upper table (10 or 12 inches higher than the lower) supports the outstretched arms and the head. The other table supports the lower limbs as high as the upper third of the thighs. The position of the tables is of the greatest importance. *the space between them must be so wide that the trunk is entirely unsupported.* If the chest or the pelvis is in any way supported, adequate hyper-extension is prevented. The muscular spasm of a conscious patient gradually relaxes, and within a few minutes the

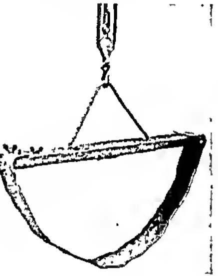


FIGURE 33

Sling for decompression of spinal fractures

The wooden board is 22 in. long and the sling itself about 40 in; this is made of strong mackintosh (two to four thicknesses) to which plaster will not adhere, and which is easily cleaned, it is detachable from the board at one end, where it is reinforced by a narrow metal plate between its layers. The plate has two holes in it to fit on to two bolts at the end of the board

spine sags downwards to the limit of normal hyper-extension. In this position a plaster cast is applied. The entire trunk is accessible, so that the cast can be made to extend from the manubrium to the symphysis pubis.

This method is most suitable for the reduction of fractures of the lumbar vertebrae, as the hyper-extension produced is maximal in this relatively mobile part of the spine. It is not so satisfactory when used for fractures of the thoracic spine. Since the hyper-extension is concentrated in the lumbar region, it is sub-maximal at the site of fracture, with the result that deformity may be imperfectly corrected.

Method of slinging in the dorsal position.—This method is particularly advised for fractures of the thoracic vertebrae, as it ensures that maximal hyper-extension is obtained at the site of the fracture. A simply made sling for use with this method is illustrated in Fig. 33.

The sling is passed under the back at the site of fracture, and is

raised vertically to the cross-beam of a Balkan frame, or to an overhanging arm attached to the head of the bed (Fig. 34). A pulley block and tackle will greatly facilitate the operation. The sling is raised till the *shoulders and pelvis are well clear of the bed, and the* entire weight of the patient rests on the sling and on the heels. Sand-

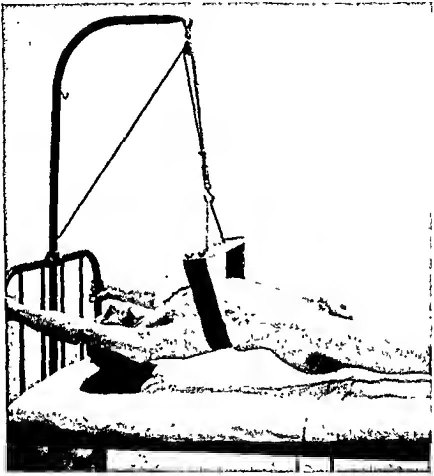


FIGURE 34

Reduction of a compression fracture in the thoracic region, by the method of vertical slinging in the supine position. (The sandbag below the buttocks has been omitted.)

bags are placed under the head and buttocks to steady the patient during the application of the plaster cast.

Anaesthesia.—An anaesthetic is of course essential for forcible hyper-extension, but it is not necessary for the other methods of reduction described. The pain produced is not severe, and it is felt in the stretched abdominal muscles rather than in the back. The method of slinging involves rather less discomfort to a conscious patient than does the Watson Jones procedure, in which a considerable strain is placed on the outstretched arms. In some cases, however, an

anaesthetic will be required. This offers no difficulty when the patient is slung in the dorsal position, but with the Watson Jones method the anaesthetist has several problems with which to contend, and one or more assistants are required to steady the patient's arms on the table, to prevent him from sliding off.

Application of a plaster jacket. *Padding.*—Bulky padding should never be used. Bandages, whether of lint, domette or wool, are unsatisfactory, as the turns soon become displaced and collect into uneven folds. The most satisfactory padding for a spinal plaster is undoubtedly obtained from thin felt or thick flannel. A jacket is

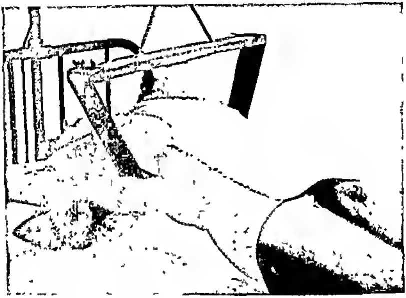


FIGURE 35

The felt jacket is applied *outside* the sling It is cut to fit as accurately as possible and is stitched edge to edge.

cut to fit as accurately as possible, and is stitched edge to edge (Figs. 32 and 35). The care given to this will be amply repaid later. Stockinette alone is too thin for the patient's comfort, but is satisfactory if combined with pads of felt to protect the bony prominences—one long pad over the spinous processes, and two small ones over the anterior superior spines. Adhesive felt is applied directly to the skin; non-adhesive felt should be *stitched* to the stockinette. For the Watson Jones method of treatment, the padding should be applied before the patient is placed in position between the two tables; this lessens the strain placed on a conscious patient, or shortens what must always be a difficult anaesthesia. With the method of slinging, there is no objection to applying the padding after full hyper-extension has been produced. If a felt or flannel jacket is being employed, it can then be fitted more accurately to the final posture of the patient (Fig. 35).

The plaster is now rapidly applied and is carefully moulded to the body contours. The exact depth of the cast at the back is immaterial, *but it must cover the anterior aspect of the body from the manubrium sterni to the symphysis pubis.* Considerable trimming may be necessary around the anterior axillary folds and in front of each thigh, where flexion of the hip to a right angle must be provided for. The felt is trimmed to leave a margin of about 2 inches; this is turned over the edge of the plaster, and incorporated in a fresh bandage. The margins of the cast are now relatively soft and regular, so that they do not chafe. The presence of the sling interferes very little with the

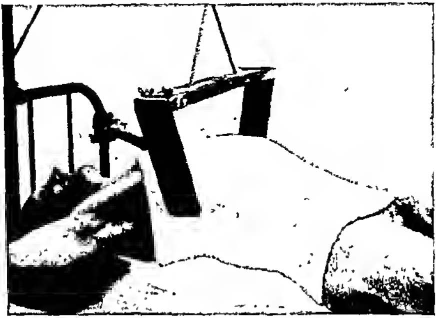


FIGURE 36

The plaster cast applied. The edge of the plaster has been trimmed where necessary; the felt has been turned over, and incorporated in a fresh plaster bandage.

plastering; in the finished plaster, it emerges by two narrow slits (Fig. 36). The sling is usually removed without great difficulty, but its withdrawal is facilitated if it has been greased before application. Alternatively it may be enclosed in a sheath of cellophane, which is left *in situ.*

For fractures involving the upper half of the thoracic spine, it is necessary to include the neck in the plaster cast, as in the treatment of cervical fractures (Figs. 45 to 47).

A hard mackintosh-covered pillow should be placed under the concavity of the cast until drying is complete. A window cut in the epigastric region adds to the patient's comfort, and is usually advisable when reduction has been carried out by the sling method. A plaster cast applied by the Watson Jones method has been moulded to the

sagging abdomen, and is therefore more roomy in this region, so that a window is not so necessary. If the patient complains of pressure over the spinous processes at the site of lordosis, a narrow window should be cut in the plaster, ***but not in the felt***, at this point. Windows should never be cut till the plaster is dry.

After-treatment.—If the reduction has been shown by a lateral radiograph to be satisfactory, the patient is allowed up as soon as he is able—usually in two to five days' time. He is then encouraged to lead a normal life, and to get as much exercise (*e.g.* walking) as

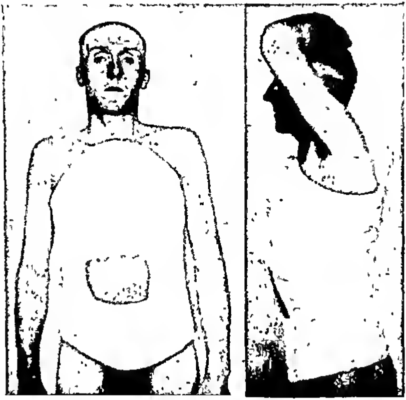


FIGURE 37

The completed plaster cast for a lower thoracic fracture, showing how hyper-extension is maintained in this segment of the spine. The plaster extends in front from the manubrium sterni to the symphysis pubis. (The window has been made rather small, but this patient had no discomfort.)

possible. Suitable exercises for the spinal muscles are prescribed, and it may be possible to have the patient attend a special gymnastic class, such as are conducted in many hospitals. The plaster cast should be worn for not less than four to six months, during which time lateral radiographs are taken at monthly intervals to ensure that re-displacement is not taking place. If the plaster cast becomes loose a new one should be applied in maximal hyper-extension.

After removal of the cast, exercises and physio-therapy are continued. The wearing of a posterior spinal support is condemned. "Either the fracture is not firmly consolidated and a brace is inadequate, or the fracture is consolidated and a brace is unnecessary" (Watson Jones).

DISLOCATIONS AND FRACTURE DISLOCATIONS OF THE THORACIC AND LUMBAR SPINE

Dislocations of the thoracic and lumbar spine, like compression fractures, are usually caused by flexion injuries. Owing to excessive

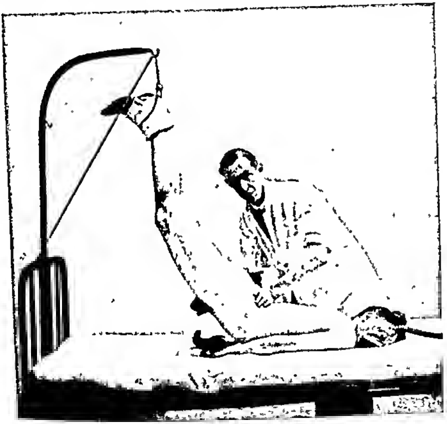


FIGURE 38

The method of obtaining hyper-extension of the spine suggested by Davis. This is particularly suitable for use in cases of fracture dislocation, where pressure is exerted on the spine just *distal* to the site of dislocation.

hyper-flexion alone or to a shearing force which drives the upper part of the spine forwards, dislocation occurs between two vertebrae, the upper one (with the segment of spinal column above) being displaced forwards on the lower. There is usually an accompanying fracture of the body, the laminae or the articular processes. The normal alignment of the vertebral canal is disturbed, and the spinal cord is compressed to a varying degree between the lamina of the disloc

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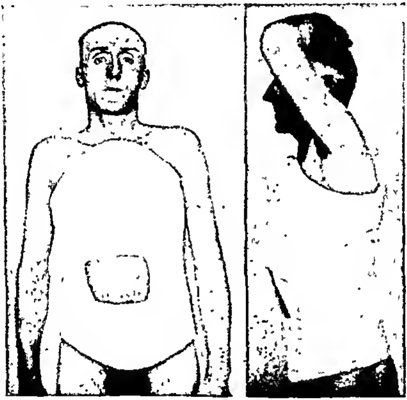

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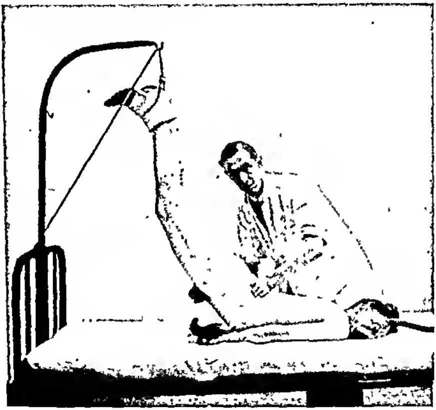

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The method of obtaining *hyper-extension* of the spine suggested by Davis This is particularly suitable for use in cases of fracture dislocation, where pressure is exerted on the spine just *distal* to the site of dislocation.

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vertebra, and the upper posterior margin of the vertebral body below. Partial or complete paralysis may therefore be present.

Immediate reduction is indicated in all cases of dislocation, in order that pressure on the cord due to bony deformity may be prevented or relieved. As in the case of compression fractures, the deformity can usually be satisfactorily reduced by hyper-extension, but forcible hyper-extension as illustrated in Fig. 31 is dangerous and must be avoided. The method of Watson Jones (Fig. 32) is usually adequate, but if this fails the patient should be slung up by the ankles, as shown in Fig. 38. The fracture dislocation will then become spontaneously reduced, or replacement may be effected by gentle pressure on the spine just *distal* to the dislocation.

Occasionally in the thoraco-lumbar region of the spine dislocation may occur without any fracture being present, but it is then likely to be complicated by transposition and interlocking of one or both pairs of articular processes. Such a dislocation is unlikely to be reduced by hyper-extension, and open operation should be undertaken.

Plaster fixation.—After reduction of the dislocation, a plaster cast is applied by one of the methods described for compression fractures, and the after-treatment is on similar lines.

Cases with paraplegia.—No time should be lost in reducing the displacement, as it is seldom justifiable to assume that the damage to the cord is irrecoverable. In the lumbar region the lumen of the canal is large, and the nerves of the cauda equina are not easily torn, so that there is a reasonably good prospect of recovery if pressure due to bony deformity is relieved. In the thoracic region, the prognosis is much more grave, as the cord fills the relatively narrow canal, and is likely to be irreparably damaged even by a moderate degree of displacement.

The desirability of plaster fixation is a matter of controversy, as pressure sores are very liable to develop beneath the cast. It is as well to postpone the decision for several days after reduction has been carried out. During this time the patient is laid on a "hyper-extension mattress" (Fig. 30). The progress of the case or the demands of nursing will usually determine the course of treatment then to be adopted. Patients who show rapid recovery of cord function can be treated in an ordinary plaster jacket: for those in whom prolonged paralysis seems likely, a plaster shell (p. 56) is more suitable.

DISLOCATIONS AND FRACTURE DISLOCATIONS OF THE CERVICAL SPINE

Dislocation of the cervical spine is a frequent injury resulting from hyper-flexion of the neck or from sudden forward jerking of

the head. The deformity consists of forward displacement or tilting of a vertebra on the one immediately below. Owing to the laxity of the cervical articulations, dislocation unaccompanied by fracture is relatively more common than in the lower segments of the spine. In incomplete dislocation or *subluxation*, the articular processes do not actually over-ride one another, and there is no more than slight tilting forward of one vertebra on another. The deformity may be

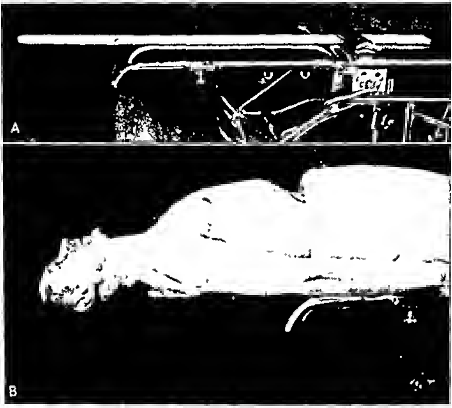

FIGURE 39

Reduction of a subluxation of cervical spine.

A.—A convenient method of fixing the wooden board to an operating table, by clamping it under the kidney bridge. A Liston's long splint may be used for the purpose, although it is a little clumsy. A thinner board 3 in. wide is advised. The end, which should be rounded, projects 12 in. beyond the end of the table.

B.—Patient in position on the table. The end of the board lies at the cervico-thoracic junction, and the neck is hyper-extended by the weight of the head In this position, plaster is applied.

recognizable only if the neck is X-rayed in flexion (Watson Jones). In complete dislocations, the articular processes on one or both sides slip forward over the articular processes of the vertebra below, and become locked in this abnormal position. In some cases complete dislocation may be accompanied by fracture of the articular processes, so that interlocking does not then occur.

Symptoms resulting from pressure on the spinal cord are usually

present in all types of cervical dislocation. These vary from slight intermittent "root" pains to complete paraplegia.

FIGURE 40
Method of exerting traction on the cervical spine (Taylor.)
(For description, see text.)

Partial dislocation (Subluxation).—In partial dislocation and in dislocation associated with fracture of the articular processes, reduction can usually be effected by simple hyper-extension of the neck,

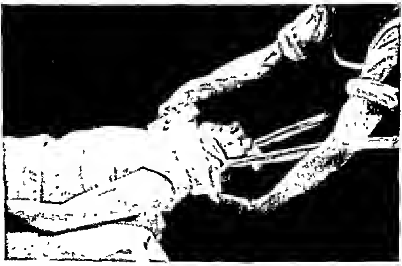

FIGURE 41
The application of the plaster, while the traction is maintained as before

when the displaced vertebra will slip back into alignment. The position is then maintained by a plaster cast. A satisfactory method

of obtaining hyper-extension, and of supporting the patient for the application of plaster, is shown in Fig. 39. A long spar of hard wood 3 inches wide is fixed to an operating table (or nailed to a wooden table), so that it projects about 12 inches beyond the end. The patient is placed on the table so that the free end of the wood lies opposite the cervico-thoracic junction. The head is gradually lowered till the neck is in full extension. A plaster cast is then applied in this position. The different types of cast which may be employed are illustrated in Figs. 45 to 47.

Dislocation with interlocking of the articular processes.—In this injury, reduction cannot be obtained by hyper-extension alone. *Strong* traction is required to undo the over-riding of the articular processes, before the displaced vertebra can slip backwards into position.

Method of forcible traction.—In this method described by Taylor, *immediate* reduction is obtained by manual traction and manipulation. The method is illustrated in the accompanying photographs (Figs. 40 and 41). Two domette or calico bandages are passed around the chin and occiput, and after being knotted together at the ears they are tied round the operator's hips. The patient's legs are tied to the foot of the table or secured by an assistant, and the operator, by backing away from the table, applies gradual and increasing traction to the neck muscles. By holding the head and neck between his two hands, he maintains absolute control of the whole process. After traction for a period varying with the strength and spasm of the neck muscles, the neck will be found to elongate gradually; the over-riding articular processes unlock, and the dislocated vertebrae slip into their normal relationships, usually with an appreciable click. If the dislocation is unilateral, rotatory movement of the head may be required before the interlocking can be undone. The direction of traction is then lowered to promote hyper-extension. The traction is maintained as before, and the operator has his hands free for the application of a plaster cast.

Continuous traction.—This has frequently been attempted by means of some form of sling which takes its purchase from beneath the chin and the occiput (*Fig.* 58), but the amount of traction required is usually far in excess of that which can be tolerated for any length of time.

The method has been repopularized by the introduction of special skull calipers (Figs. 42 and 43). These can be applied under local anaesthesia. A 1 inch vertical incision is made on each side above and in front of the auricle, and a small trephine hole is cut in the outer table of the skull, above the temporal line. The points of the calipers are hooked under the bone margin. Deep penetration is prevented by an adjustable flange. Weight traction is applied over a pulley attached to the head of the bed, and counter-traction is

provided by raising the head of the bed on blocks. Watson Jones recommends that traction should begin with a weight of 15 to 20 lbs.,

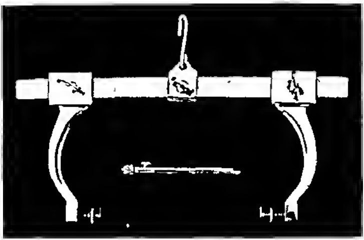

FIGURE 42

Anderson's skull calipers with special guarded trephine. Note the shape of the points of the calipers, and the adjustable flange which prevents deep penetration.

and that X-rays should be taken every 15 minutes until the articular processes are disengaged. The pulley is then lowered so that the

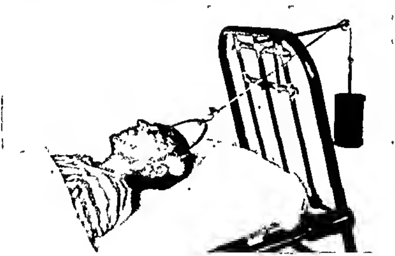

FIGURE 43

Skull calipers in use for continuous traction.

cervical spine is extended. When reduction is complete, the weight is reduced to 10 or 12 lbs.

This method of continuous traction should probably be reserved

for special cases. For the reduction of recent dislocations it has no advantages over Taylor's method, which has the essential virtue of simplicity. Continuous traction, however, is indicated for dislocations which have been present for some time, when prolonged traction may be required to stretch the shortened anterior ligaments. It will also be necessary in cases where re-displacement tends to recur in spite of immobilization, or where the patient's condition does not permit the application of plaster.

Figure 44

Method of suspension for the purpose of applying a cervical plaster cast. The webbing sling is adjusted so that the neck is hyper-extended. Considerable traction can be tolerated without discomfort.

Application of plaster.—If a portable X-ray apparatus is available, arrangements should be made for films to be taken after attempted reduction and before the plaster is applied. If the operator is not satisfied that reduction is complete, further manipulation may be carried out or plaster fixation may be postponed until the effect of continuous traction has been tried.

The plaster cast may be applied with the patient in one of the positions already described (Figs. 39 and 41). Alternatively, after the dislocation has been reduced, and if there appears to be no tendency to immediate re-displacement, the patient may be sat upright, and vertical traction applied by means of a head sling, which must be adjusted so that hyper-extension is maintained (Fig. 44).

The different types of cast which may be used are illustrated in Figs. 45 to 47. All require careful padding, particularly over the shoulders, and around the lower jaw. The cast in Fig. 45 affords the most complete immobilization; it is moulded closely to the lower jaw and occiput, and extends below to the level of the umbilicus. The cast depicted in Fig. 47 is similarly moulded above, but does not encircle the thorax. The immobilization is less complete, but is usually adequate, and the cast is more contentedly tolerated. During the application of a plaster which is moulded to the lower jaw, the

mouth should be gagged open to about $\frac{3}{4}$ inch, to allow for mastication afterwards. In addition the larynx should be protected with a large pad of wool, or alternatively a window should be cut in this area

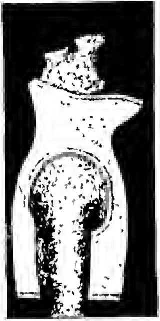

FIGURE 45

FIGURE 46

FIGURE 47

(Fig. 47). A greater range of movement of the jaw may be allowed if the plaster is carried round the forehead as a bandeau (Fig. 46). A cast of this description is more difficult to apply. It must be moulded tightly down to the supra-orbital margins, as except in patients with an unusually prominent forehead, there is an un-

avoidable tendency for the head to slip forwards out of the bandeau so that flexion may occur.

Cervical plasters should be worn for two to three months after the injury. Lateral radiographs are taken at regular intervals to ensure that displacement has not recurred.

Cases with paraplegia.—Cervical dislocations associated with paraplegia are usually rapidly fatal. The displacement should be reduced by one of the methods described, and the neck should be kept hyper-extended by a pillow placed under the shoulders. In patients who survive, the reduction may be maintained by continuous traction.

IV

TUBERCULOSIS OF THE SPINE (POTT'S DISEASE)

TREATMENT IN RECUMBENCY

RECUMBENCY is the first essential in the local treatment of all forms of tuberculosis of the spinal column. It consists in keeping the patient lying in such a position that movements of the spine are abolished, and weight-bearing is removed from the vertebrae. In addition such treatment serves to prevent or to correct kyphotic deformity, which is due to the partial collapse of the bodies of the one or more vertebrae affected by the disease, and is aggravated not only by weight-bearing, but also by muscular spasm. Deformity can usually be minimized if an early diagnosis is made, and strict recumbency is maintained from the outset. If a kyphosis is present at the commencement of treatment, it may be largely corrected or compensatory curves may be developed above and below the deformity.

Satisfactory recumbency cannot be secured with an ordinary bed—even on a firm mattress resting on fracture boards, as it is difficult to secure adequate fixation of the segments of the spine above and below the diseased area, and any immobilization obtained will be constantly interrupted when the patient is moved for nursing purposes. The following methods are in general use.

Treatment on special frames.—The first two frames described, the Bradford and the Whitman frame, consist of narrow rectangles of gas pipe or steel tubing of about ¾-inch diameter. The patient lies on canvas which is tightly stretched between the two sides of the frame and is laced on the under surface. Immobilization is secured by webbing straps or binders passed round the thorax, pelvis, and thighs. The child is thereby converted into a rigid object, capable of being carried from one room to another, or into the open air, without interruption of the immobilization. The canvas is usually applied in two sections, or a hole is cut in it to provide facilities for nursing, and with the same object the frame may be raised by wooden blocks placed under each end.

The Bradford frame (Fig. 18) is made a few inches longer than the patient, and its width is equal to the distance between the shoulder tips. The thorax is usually secured to the frame by two canvas straps, and the pelvis by a broad binder. The lower limbs are also similarly fixed.

The Whitman frame (Fig. 19) is a modification of the Bradford frame and has largely replaced it at the present time. It is only four-

fifths as wide as the patient, the side bars lying opposite the glenoid fossae and acetabula, so that it interferes as little as possible with clothing and nursing. It is angled opposite the site of the disease, in order to provide continual hyper-extension in that situation. Two

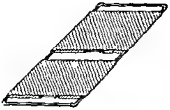

Figure 48

The Bradford frame.

Figure 49

The Whitman frame.

strips of thick felt are usually sewn to the canvas on either side of the mid-line at the site of angulation, to prevent undue pressure over the spinous processes at this point. The angulation of the frame may be increased at intervals until the kyphosis is reduced, this method being much more efficacious than any form of padding on a flat surface. The child is usually placed on the frame wearing a thick woollen vest,

Figure 50

Patient immobilized on a Whitman frame. Note the angulation of the frame at the site of the disease, and how traction is applied to head and lower extremities.

(Mr. R. I. Stirling's case.)

and is secured by an arrangement of straps or binders. Further outer clothing may include the frame.

With both types of frame, traction on the head and lower extremities may be carried out towards the ends of the frame; this is usually advisable in the early stages of treatment, as otherwise the immobilization of the affected segment of the spine is liable to be very imperfect. Traction is particularly desirable in the treatment of all cases with spinal cord involvement.

The Thomas double frame is illustrated in Fig. 51. It provides a well-padded leather-covered surface for the back and for each leg. An adjustable head-piece is fitted which secures fixation of the head in any desired position, and allows traction to be applied to it. Pro-

vision is also made for traction on the legs, by means of extensions resembling the ends of Thomas's splints carried beyond the padded limits of the frame. Metal wings attached to the frame are moulded round the sides of the trunk so that lateral movement is prevented. The frame must be well fitted to the size of the child, so that it should

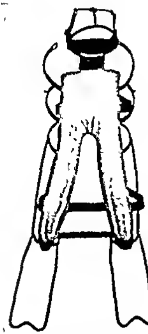

FIGURE 51

The Thomas double frame with adjustable head-piece.

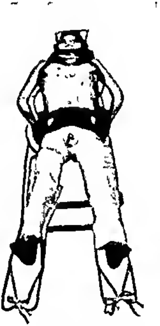

FIGURE 52

Patient in position. Traction applied to head and lower limbs.

(Courtesy of Messrs E. Arnold & Co., London.)

be made to measure in each case, or a large stock should be available. The method is, therefore, a somewhat expensive one.

In all cases where a frame is employed in treatment, due attention must be paid to the skin of the back, and for this purpose the child is lifted off once a day, and placed face downwards on a flat surface. The skin is carefully washed with soap and water, dried with spirit and powdered.

Treatment by plaster shells.—Mercer gives precedence to fixation by means of a plaster shell, as this is more comfortable and fits more accurately. It is necessary that the shell should be made with the spine hyper-extended as far as the activity of the disease allows. Either a posterior or an anterior shell may be employed.

The posterior shell is made while the patient lies in the prone position, with the thorax and head raised on pillows, and the legs slightly abducted (Fig. 53 A). The shell should extend at least from the back

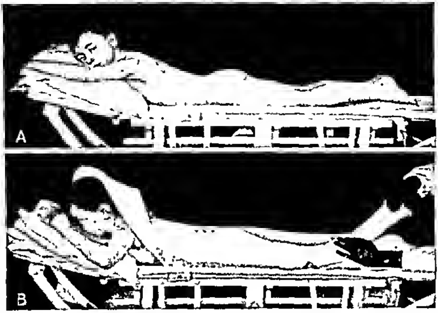

FIGURE 53

The making of a posterior plaster shell.

A.—The patient is laid in the prone position, with the head and the upper part of the thorax raised on pillows.

B.—He is covered with a large sheet of thin felt, and the plaster is applied in long swathes. The shell should extend more than half-way round the circumference of the body.

of the neck to the knees, but it is more often made to give support to the whole body from head to foot. The padding is conveniently made from one large sheet of thin felt, which is laid over the patient. Plaster bandages are then laid on in long swathes, which are moulded to the contours of the body. The plaster should extend well forward on the lateral aspects of the body, and on each side of the legs. Aluminium strips may be incorporated in the plaster to give strength to the shell without too much additional weight. After the shell has set, it is lifted off and the edges trimmed. The felt margin is turned over and secured by stitching or by further plaster bandages. Mercer advises that an additional anterior shell or lid should also be constructed. When the two halves are bandaged together, a complete plaster box is formed in which the patient can be rolled over. This allows daily attention to be paid to the skin of the back without interrupting the immobilization. The shell is usually

FIGURE 54

Completed posterior shell.

(Courtesy of Messrs E. Arnold & Co.)

raised on wooden blocks or placed on a frame, so that nursing may be made easier.

The anterior shell is particularly suitable for low thoracic and lumbar disease. It is no less well tolerated than a posterior shell, and it has the advantage that any movements which the child may

FIGURE 55

The posterior shell in use. A wooden board has been incorporated in the plaster. The whole is raised on a Whitman frame, supported on blocks

(Mr. R. I. Stirling's case.)

make in order to look about him are in the direction of hyper-extension, and, as such, may therefore be encouraged. The shell is made in a similar manner to the posterior one, but two small windows are cut out for the anterior superior iliac spines, and a larger one for nursing purposes. It is usually mounted on a special wooden frame (Fig. 57), and provision is made for supporting the head, either by an extension to the frame, or by a padded ring incorporated in the shell. Mercer believes that the anterior shell should be universally adopted

FIGURE 56

Patient in position for the making of an anterior plaster shell.

unless there are contra-indications to its use. The contra-indications suggested are abscesses which are discharging anteriorly, spastic conditions, and paraplegia.

It is often advised that anterior and posterior shells should be used alternately in the treatment of an individual case. Both types of shells have disadvantages when applied for long periods, as immobilization in the supine position is liable to lead to renal calculus for-

mation, while patients kept in the prone position often develop digestive disturbances. In addition, such alternation must provide a very welcome change in the monotony of prolonged treatment.

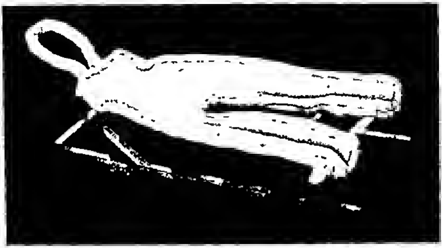

FIGURE 57

Anterior plaster shell mounted on wooden frame. The head rests on a padded metal ring incorporated in the shell. Windows are cut in the plaster (but not in the felt) over the anterior superior spines.

Treatment as applied to Individual Regions

Cervical spine.—Continuous traction should be applied to the head during the early stages of treatment, by means of a special sling consisting of a band of webbing or light canvas passing round the

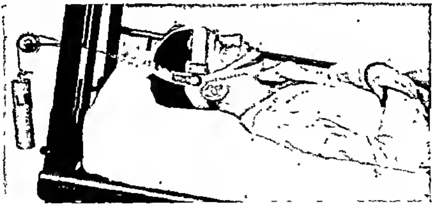

FIGURE 58

The application of continuous traction to the head, in the treatment of Pott's disease of the cervical spine.

forehead and occiput and fitted with a chin strap. 2 to 5 lbs. weight is usually attached. The patient may be treated in an ordinary bed, the head of which is raised to provide counter-traction (Fig. 58), but more satisfactory immobilization, together with greater ease of

nursing and transportation, is obtained if the patient is treated on a special frame. In the later stages, treatment may be continued in a posterior plaster shell, with an accurately fitting head-piece.

The upper thoracic spine presents a special problem in regard to the difficulty of obtaining adequate hyper-extension. In the early stages, treatment is perhaps best carried out on a suitably angled Whitman frame, with traction applied to the head. Later, a plaster shell may be fitted to maintain the extension in the diseased segment (Fig. 59). The patient's head must be securely fixed to the shell by straps, as all movement must be prevented.

Lower thoracic and lumbar regions.—Satisfactory recumbency may be obtained either on a frame or by means of a plaster shell. Special

FIGURE 59

Type of posterior shell used in the treatment of high thoracic disease.
(Courtesy of Messrs. E. Arnold & Co., London.)

advantages are claimed for the anterior shell in the treatment of disease in this segment of the spine (p. 58). If a frame is employed, traction should be applied to the lower limbs.

Duration of recumbency.—Recumbency must be maintained until the disease has ceased to spread, and the process of cure has begun. The required duration of such treatment varies within wide limits, but a period of one year is suggested as the minimum, and eighteen months to three years as the average. In general, it may be said that the higher the lesion, the longer will be the period of recumbency required. Fraser gives the following indications as being favourable to the commencement of ambulatory treatment: (1) disappearance of pain; (2) no increase in deformity; (3) normal temperature for some months; (4) attempts on the part of the child to get up; (5) satisfactory increase in weight; (6) radiological evidence of re-calcification and consolidation of the diseased vertebrae.

AMBULANT TREATMENT

When there is definite evidence that the process of cure has begun, the child may be allowed gradually to assume the vertical position, but some form of spinal support is essential, and must be

maintained until consolidation of the diseased vertebrae is complete—often a matter of some years. The necessary support may be provided by a plaster jacket, or by special appliances such as a spinal brace or celluloid jacket, which are made by the instrument maker.

The plaster jacket is probably the most satisfactory as a good fit is assured and it is well tolerated by the patient. It can be more

FIGURE 60

Suspension of patient for the application of a plaster jacket. The toes only are allowed to touch the ground.

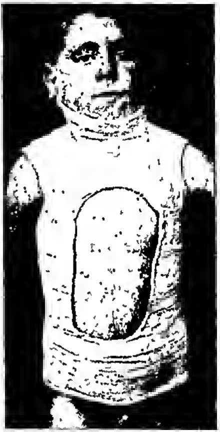

FIGURE 61

Plaster jacket for upper thoracic or cervical disease. Note the moulding of the plaster round the lower jaw and occiput, and how the window extends well up on to the chest.

Courtesy of Messrs. A. & C. Black, Ltd., London.)

accurately moulded to the contours of the body if it is applied with the patient in the upright position. For this purpose the child is suspended by means of a head sling, the toes only being allowed to touch the ground (Fig. 60). The plaster is applied over an undervest or layer of stockinette and is padded over the bony prominences. In disease of the lower thoracic and lumbar segments, the jacket should extend in front from the manubrium to the symphysis pubis. In cases where the upper thoracic or cervical spine is affected, the cast is carried up to include the neck (*Fig. 61*), and is moulded below the lower jaw and

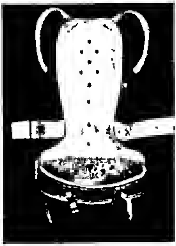

FIGURE 62
Posterior spinal support of Thomas

FIGURE 63
Spinal support in use

FIG. 63

FIGURES 64 AND 65
Spinal support fitted with collar to give support to the head. For use in cases of high thoracic or cervical disease.
(Figs. 62 to 65 Courtesy of Messrs. E. Arnold & Co., London.)

occiput. Careful padding is required over the shoulders and around the neck and jaw. A large window should be cut over the chest and abdomen to prevent constriction.

The spinal brace must be made with great care under the supervision of the surgeon, as its efficacy depends entirely on a correct fit. An efficient form of brace is the *posterior spinal support of Thomas*, illustrated in Figs. 62 to 65. This provides no vertical support, its sole action being the prevention of forward bending of the spine. The essential features of the support are the firm fixation of the pelvis by means of the broad pelvic strap, and the pulling back of the shoulders to the frame by the shoulder straps. A collar can be attached to the brace to provide support for the head, and is employed in cases of disease above the sixth thoracic segment (Figs. 64 and 65). The advantages of a spinal brace over the plaster jacket lie in its comparative lightness, and in the absence of constriction round the chest. On the other hand, it is usually more irksome to the child, and is very liable to be removed by an unscrupulous parent. Frequent alterations or renewals are essential to meet the requirements of a growing child, and the plaster jacket has advantages in regard to both simplicity and expense.

FIGURE 66

Celluloid jacket in use. Note how it is moulded to support the head.

(Courtesy of Messrs. E. Arnold & Co., London)

Celluloid or leather jackets are light and comfortable to wear, and as they are made on a cast of the patient, an accurate fit can be guaranteed. They are particularly suitable for the treatment of cervical disease. The same difficulty exists, however, in regard to the growing child, and the method is expensive.

V

FRACTURES OF THE RIBS

TREATMENT consists in controlling as far as possible the movements of the affected ribs. This provides not only for more rapid union of the fractures, but also affords great comfort to the patient, and enables such important reflexes as coughing to be carried out without the production of pain.

Immobilization is usually secured by adhesive strapping, and is only effective if this is applied round the entire circumference of the

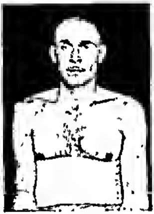

FIGURE 67

Strapping applied for the treatment of fractures of the lower ribs.

FIGURE 68

Method of applying the strapping when the upper ribs are affected.

thorax. Strapping applied to one side of the chest alone is by comparison much less satisfactory; this gives only limited support and soon becomes detached. Either plain adhesive, or expansile strapping of the *Elastoplast* type may be used. In all cases the strapping is applied round the lower part of the chest below the nipple line. This not only provides for immobilization of the lower ribs, with which it is in direct contact, but it also limits the movements of the upper ribs, because the thorax moves as a whole. When however the upper ribs are affected, an additional band of strapping may be carried above the nipples, and further strips should be placed over the shoulder on the affected side (Fig. 68). In addition to limiting the respiratory excursion, this also serves to prevent the upper ribs being dragged upon when the arm is raised. *The strapping should be applied while the chest is in the position of full expiration.*

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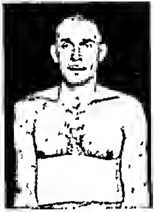

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Instead of adhesive strapping, a circular swathe may be made of plaster of Paris bandages applied directly to the skin. In order to prevent this from slipping down, a flannel or domette bandage is passed over the shoulder and incorporated in the plaster (Fig. 69).

FIGURE 69

Immobilization of the lower ribs by a circular swathe of plaster of Paris bandages applied directly to the skin. A shoulder strap of flannel bandage, which is incorporated in the plaster, prevents it from slipping down.

The patient's wishes may be studied in regard to the duration of the treatment. Some patients will appreciate for many weeks the comfort which it confers.

PART III

SHOULDER GIRDLE AND UPPER EXTREMITY

VI

INJURIES OF THE CLAVICLE

FRACTURE OF THE CLAVICLE

IN the typical fracture of the clavicle which occurs at the junction of the middle and lateral thirds of the bone, the displacement is usually characteristic. The lateral fragment is displaced downwards, forwards, and medially by the weight of the arm, while the medial fragment is elevated by the pull of the sterno-mastoid muscle. A variable degree of over-riding of the fragments is present.

Reduction.—Reduction can usually be effected without difficulty by pulling the shoulder outwards, backwards, and upwards. The

FIGURE 70

Method of reducing a fracture of the clavicle.

outward pull may be obtained by levering the upper arm over the clenched fist placed in the axilla (Fig. 70). The forward and downward displacements are rectified by bracing back the shoulders and by elevating the arm on the affected side.

Immobilization.—While reduction of the fracture is usually easy, the maintenance of the position after reduction is a matter of considerable difficulty, and the large number of methods described indicate that none has been found to be entirely satisfactory. The "*three handkerchief method*" will generally be found to give good results, as it fulfils the essential requirements of bracing the shoulders back with the minimum of discomfort to the patient, and without interfering

with movements of the shoulder joint, which, in old people at least, is liable to become the seat of troublesome stiffness afterwards. At the same time, elevation is obtained by the use of a sling fitted to give support to the elbow. In addition, two or three strips of adhesive

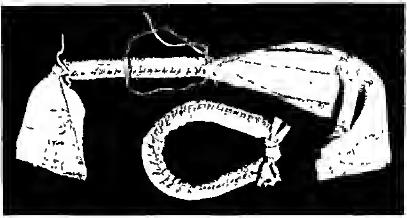


FIGURE 71

Method of preparing the padded rings for treatment of fractured clavicle. These are made from strips of felt or cotton wool 16 to 18 inches long, rolled in a 6 inch flannel or calico bandage, and secured by stitching

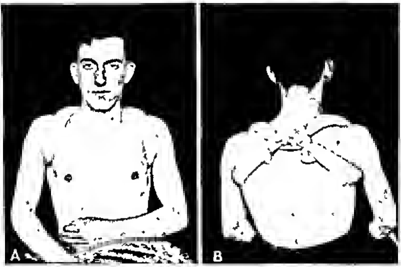


FIGURE 72

The "three handkerchief method" of treating fractured clavicle, using the padded rings shown in Fig 71 In the anterior view (A), the method of strapping is also seen. (The strapping should extend behind to the lower angle of the scapula: for the sake of clearness, this has not been shown. For the same reason, the sling has been omitted.)

strapping may be placed across the shoulder over the site of fracture and over the medial fragment, after the method of Wharton Hood. The efficacy of the strapping in preventing elevation of this fragment

is doubtful, but it gives a sense of support and renders the patient more comfortable.

The "three handkerchief method" is illustrated in Figs. 71 and 72, where it has been carried out, not by handkerchiefs, but by means of two well-padded rings made of strips of felt or cotton wool, rolled in a flannel or calico bandage. These are slipped over the shoulders and pulled firmly together at the back by means of a third piece of bandage, in order to brace the shoulders back. As the slings work slack, daily tightening of the connecting bandage is required, and the patient must be instructed to have this carried out.

After-treatment.—The padded rings are worn for two or three weeks and the sling for a week or so longer. In old people steps should be taken to guard against stiffness of the shoulder joint following the injury. The sling is removed at intervals after the first week to allow massage and active movements to be carried out.

DISLOCATION OF THE ACROMIO-CLAVICULAR JOINT

The lateral end of the clavicle is usually displaced upwards and overlies the acromion process. The dislocation is reduced by a manoeuvre similar to that described for fractured clavicle. While the shoulder is levered outwards and elevated, the lateral end of the clavicle is pressed downwards into position. Owing to the tearing of the coraco-clavicular ligaments, re-displacement is very liable to occur, but it can usually be prevented by the method shown in Fig. 73, where the lateral end of the clavicle is held down by adhesive strapping passed round the upper third of the forearm. The skin over the clavicle and ulnar border of the forearm is protected with felt pads. As the strapping stretches with the weight of the arm it should be re-applied every four or five days. Fixation must be continued for at least four weeks.

FIGURE 73

Method of treatment of dislocation of the acromio-clavicular joint.

Recurrence of the displacement is fairly common, and in such cases operative fixation may be undertaken. The disability however is usually slight.

VII

DISLOCATION AND FRACTURE DISLOCATION OF THE SHOULDER

DISLOCATION OF THE SHOULDER

FOUR positions are described in which the dislocated head of the humerus may lie—sub-glenoid, sub-coracoid, sub-clavicular and sub-spinous. Of these the sub-coracoid dislocation is by far the commonest. The sub-glenoid position is frequently found, but this probably represents only an intermediate stage of the more typical sub-coracoid dislocation.

Reduction.—A tentative attempt may be made to reduce the dislocation without anaesthesia. As a rule, however, a general anaesthetic is required, in order that muscular relaxation may be obtained.

The method of Kocher is described as being most suitable for cases of sub-coracoid dislocation. Three definite manipulations are carried out: (1) With the elbow pressed to the side, the humerus is rotated laterally by using the flexed forearm as a lever; this stretches the contracted subscapularis muscle, and brings the head of the humerus opposite the rent in the capsule. (2) The humerus is adducted by carrying the elbow forwards and medially towards the mid-line, in order that the head of the bone may be carried over the lower rim of the glenoid fossa. At this point reduction will usually occur by the head of the bone returning to its socket with an appreciable click, but in some cases the third manipulation will be required. In this, (3), the humerus is sharply rotated medially by flinging the hand over the opposite shoulder, when reduction should be completed. While this method of Kocher is usually successful, several attempts may be necessary before reduction is obtained.

The Hippocratic method, which had fallen into some disrepute, has been repopularized by Böhler. The surgeon places his stockinged heel in the axilla, and applies traction in the axis of the body, the right foot being used for a right-sided dislocation, and vice versa. As traction is applied, the arm is outwardly rotated, and the head of the bone is levered laterally over the surgeon's heel. The arm is then inwardly rotated, when the head should slip back into place. This method is often immediately successful after other manipulations have failed. Reduction is usually brought about without the employment of any great force, and the danger of injuring vessels or nerves has been greatly exaggerated.

Miller's method is also popular in the typical sub-coracoid dis-

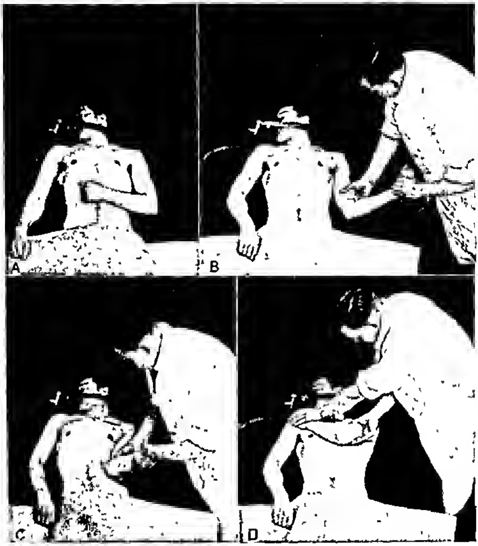


FIGURE 74
Reduction of a dislocation of the shoulder joint by the method of Kocher.
(*For description, see text.*)

FIGURE 75

The Hippocratic method of applying traction with the heel in the axilla. The head of the humerus is levered laterally over the heel, and is rotated first *laterally*, and then *medially*.

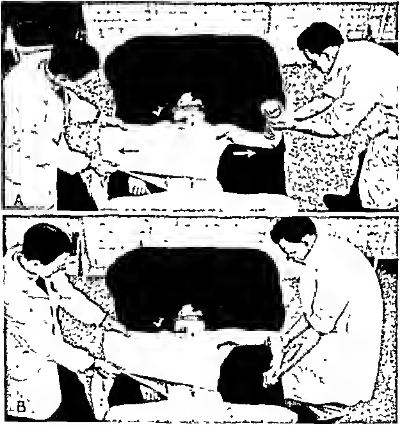


FIGURE 76

Miller's method of reducing shoulder dislocations.

A.—Strong traction is applied in right angled abduction.
B.—While the traction is maintained, the humerus is rotated medially.

location, but is more particularly indicated in posterior dislocation where Kocher's method is inapplicable. In this, traction is applied to the arm in a position of 90 degrees of abduction, while an assistant makes counter-traction by means of a roller towel passed round the trunk. The forearm is flexed to a right angle and is grasped at the elbow and wrist. Steady traction is applied in order to stretch the muscles, and the arm is then rotated medially, when the head of the bone will usually slip into its socket.

The hyper-abduction method (Fig. 77) is sometimes advised for the reduction of sub-glenoid dislocations, but these are usually reduced without difficulty by the other manipulations described, and the method has a more particular application in the treatment of fracture-dislocation and of separation of the upper humeral epiphysis.

After-treatment.—The immediate after-treatment consists in bandaging the arm firmly to the trunk over a large pad of wool placed in the axilla. Massage and active movements should be employed early, especially in old people. Recurrence of the dislocation is not uncommon, and steps should be taken to guard against this, by warning the patient against wide abduction of the arm for at least a month after the injury.

FRACTURE DISLOCATION OF THE SHOULDER

Dislocation of the shoulder joint is sometimes complicated by a fracture of the upper end of the humerus. The dislocation is almost

FIGURE 77

Traction applied to the humerus in a position of hyper-abduction. This is useful in cases of fracture-dislocation of the upper end of the humerus, where the dislocated *fragment may face in an upward direction* (Fig. 78). The method is also used in cases of separation of the upper humeral epiphysis. (Fig. 80.)

invariably of the sub-corneoid type, and the fracture usually involves the anatomical neck—less frequently the surgical neck.

Reduction.—The first essential in the reduction of the severe displacement which is present is the application of strong traction to the lower fragment, in order to provide a space into which the dislocated head may slip.

Miller's method may be successful (Fig. 76). While traction is being maintained, digital pressure is exerted on the dislocated head of the bone, in an attempt to force it back into its normal position.

The hyper-abduction method (Fig. 77) is frequently useful, and has a special application if, as sometimes occurs, the small fragment is so rotated that its fractured surface is directed upwards (Fig. 78). The patient is placed on a mattress on the floor, and the surgeon, seated on a chair behind him, pulls the arm in an upward direction against the counter-pressure exerted by his foot placed on the upper surface of the shoulder. At the same time, an assistant attempts to manipulate the dislocated fragment back into position.

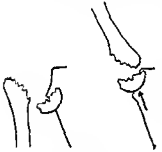


FIGURE 78

Screw traction is advocated by Böhler. A special frame is required. Skeletal traction is applied to the olecranon process with the arm in right-angled abduction, while the head of the bone is pressed into position.

After-treatment will depend upon the position of the fragments after reduction, and is similar to that described for fracture of the surgical neck of the humerus (p. 78).

Failing reduction by manipulation, open operation should be employed. Even then, reposition of the small fragment may be impossible, in which case it should be excised. A functionally useful false joint may thereby be obtained.

VIII

FRACTURES OF THE HUMERUS

FRACTURES OF THE UPPER END

FRACTURE of the greater tuberosity requires special consideration in treatment because of the limitation of abduction to which it may give rise. If no displacement exists, treatment may be carried out on conservative lines, with the employment of massage and exercises from the outset. In cases where the whole tuberosity or its

FIGURE 79

Plaster cast for fixation of the shoulder in the abducted position. *(This case was one of fracture of the greater tuberosity, with upward displacement.)* Note how the hand is supported by being included in the plaster. The cast is strengthened by a metal strip bent at the axilla and elbow (see also Figs. 96 and 97)

upper part is avulsed, it is essential that the displacement should be corrected, as, if the normal alignment is not restored, abduction of the arm may be limited by the inability of the deformed upper end of the humerus to slide below the acromion. Satisfactory position is usually obtained if the arm is immobilized in a position of wide abduction and slight lateral rotation (*see also p.* 86).

Avulsion of the tendon of the supra-spinatus is treated on similar lines. This muscle is normally responsible for the first 15 to 20 degrees of abduction, and should its function be impaired, considerable disability will result.

Fracture-separation of the upper humeral epiphysis.—Separation of the epiphysis occurs in children, and is usually combined with a fracture of the adjacent part of the diaphysis. In the majority of cases *the epiphysis with the fragment of diaphysis* is displaced laterally on the shaft, and *may in addition be abducted* and laterally rotated, *i.e.* the displacement is similar to that found in fracture of the surgical neck in adults. Reduction may be difficult as a degree of impaction is frequently present. It can be effected by the method described for fracture of the surgical neck. If this is unsuccessful, traction in hyper-abduction (Fig. 77) may correct the deformity, as the fragment is levered into position by contact against the acromion (Fig. 80). Accurate reduction is essential, for if the deformity is allowed to persist, limitation of abduction may result. Operative exposure is occasionally required.

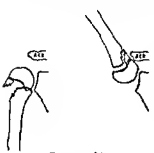


FIGURE 80

Fracture separation of the upper humeral epiphysis: *reduced by hyper-abduction*, as the small fragment is levered into position against the acromion.

FRACTURES OF THE SURGICAL NECK

Adduction fracture is the designation applied to the typical fracture of the *surgical* neck where the displacement is characteristic (Fig. 81). The small *upper fragment is abducted* and *laterally* rotated by the muscles inserted into the greater tuberosity. The displacement is thus similar to that described for separation of the epiphysis, and for the same reason it is essential that accurate reduction should be obtained.

Reduction is carried out by a manipulation which will bring the lower fragment into line with the small uncontrollable upper fragment. When the typical displacement is present, reduction is most easily obtained by applying traction with the arm in a position of abduction and lateral rotation. While the traction is being maintained, the fragments are manipulated into alignment (Fig. 82). A general anaesthetic is required in order that muscular relaxation may be obtained. After reduction has been effected, the arm can usually be brought back to the side without the position being disturbed, in which case further treatment will consist only in supporting the arm by means of a "*collar-and-cuff*" bandage

FIGURE 81

"Adduction" fracture of the surgical neck. (This rather misleading term indicates the relation of the *lower* fragment to the upper.) *Note that the upper fragment is abducted.*

FIGURE 82
Method of reducing a typical "adduction" fracture of the surgical neck of the humerus.

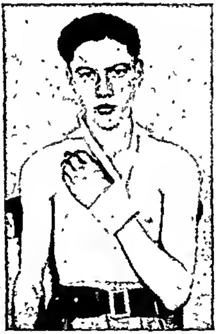


FIGURE 83
The "collar-and-cuff" method of suspending the arm. The wrist and the back of the neck are protected with felt pads.

(Fig. 83). No sling should be used to support the elbow, as the weight of the arm hanging down serves to prevent re-displacement. If satisfactory alignment cannot be maintained with the arm at the

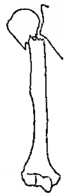


FIGURE 84

"Abduction" fracture of the surgical neck (The term denotes the relation of the lower fragment to the upper.)

side, immobilization in abduction will be required (Fig. 79). Continuous traction is rarely necessary.

Abduction fracture (Fig. 84) is comparatively rare. *The displacement is of the opposite type,* the lower fragment being displaced medially towards the axilla.

Reduction is carried out by *pulling the arm* downwards in the line of the body, against counter traction provided by a bandage passed round the axilla. In addition *the lower fragment is levered* outwards, using the closed fist placed in the axilla as a fulcrum (Fig. 85). Traction in abduction must not be carried out as the deformity will thereby be increased. If such fractures are impacted and the angulation is not excessive, it is as well to avoid interference, as the resultant limitation of movement will be slight.

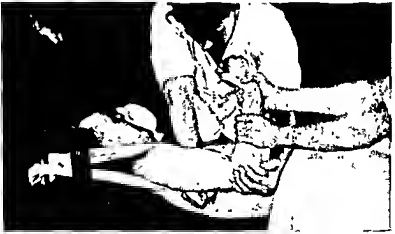


FIGURE 85

Reduction of an "abduction" fracture of the surgical neck.

FRACTURES OF THE SHAFT

The displacements found in fracture of the shaft may be produced by the nature of the fracturing force, or they may depend on muscular action, in which case the position of the fragments will vary according to the level of the fracture. In fractures of the upper third of the bone the displacement resembles that described for fracture of the surgical neck. In fractures of the middle third of the shaft, the position of the fragments is usually said to depend upon the relation of the frac-

ture to the insertion of the deltoid muscle. If the fracture is above this insertion, the upper fragment may be adducted by the muscles

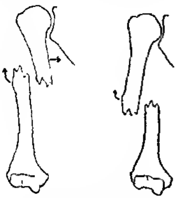


FIGURE 86

Fractures of the shaft of the humerus. Position of the fragments *in relation to the insertion* of the deltoid muscle.

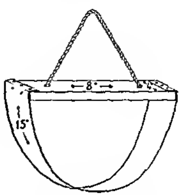


FIGURE 87

A simple sling which is most useful for applying manual *traction to the upper arm or* forearm.

attached to the bicipital groove, while the lower fragment lying on the lateral side of this is pulled upward by the deltoid and long muscles

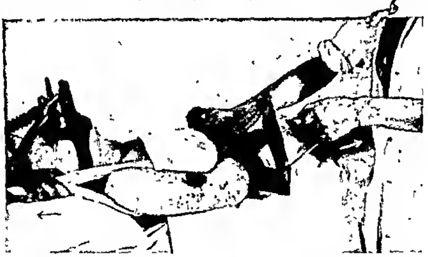


FIGURE 88

Method of exerting traction in fractures of the shaft of the humerus. The sling (Fig. 87) is a great advantage, as it leaves the dorsum of the forearm free for the application of a plaster slab. It is better that the bandage supply*ing the counter-traction should be tied to a fixed object, and not* (as shown here) held by an assistant.

of the upper arm. If the fracture is below the deltoid insertion, the displacement is likely to be in the opposite direction, as the upper fragment is now abducted by the action of this muscle (*Fig.* 86).

Reduction is carried out by manual traction applied to the arm at an angle which will bring the lower fragment into line with the upper.

In fractures of the upper third traction is applied in abduction, as in the reduction of fractures of the surgical neck (Fig. 82).

In fractures of the lower two thirds it is best to exert the pull in the line of the body, counter traction being provided by a bandage passed round the axilla and drawn upwards. A convenient method

FIGURE 89

Dorsal plaster splint applied. The traction is maintained until the splint has been firmly bandaged in position.

of maintaining such traction is illustrated in Fig. 88, and for this purpose the sling shown separately in Fig. 87 is of great assistance, as it leaves the dorsal surface of the elbow and forearm free for the application of a plaster splint.

Immobilization.

The dorsal plaster splint.—This is a most satisfactory method of providing immobilization after the fracture has been reduced. It is applied while the traction is being maintained, and is made to extend from the tip of the acromion process to the wrist or to the knuckles, and should extend more than half-way round the circumference of the limb. It is applied directly to the skin surface. The flexor aspect of the arm and forearm is covered with wool, and, before the traction is relaxed, the whole is firmly bandaged or secured with adhesive strapping.

A complete circular cast is an alternative method of treatment. A dorsal slab is first applied in the manner described, and is bandaged to the arm and forearm. While the traction is maintained, the part of the slab covering the upper arm is converted into a circular cast. After this has set, the traction is discontinued, and the cast is extended down to include the forearm. The bandage used to secure the dorsal slab may provide sufficient padding under the circular cast, or additional wool may be placed along the flexor aspect of the limb before the circular cast is applied. In general, however, it may be said that a circular cast provides no more

effective immobilization than a properly applied dorsal splint. In addition, there is more risk of interfering with the circulation of the limb. A circular cast should as a rule be split, and, during the first

FIGURE 90
Fracture of the shaft of the humerus immobilized by a posterior plaster splint. The strapping alone will not maintain the position; in the early stages the arm is firmly bandaged to the side.

twenty-four to forty-eight hours, it is a wise precaution to suspend the limb in the manner shown in Fig. 45.

The U-shaped plaster slab is advised by Böhler. This is applied over the outer and inner surfaces of the upper arm passing below the elbow. On the lateral side it extends up to the acromion, and on the

FIGURE 91
U shaped plaster splint for the upper arm—suitable for the treatment of fractures of the shaft of the humerus without displacement.

medial side as far as the axillary folds. This method, which allows limited movement at the elbow joint, is suitable only for cases without displacement.

Immobilization in abduction has much to commend it, as the alignment is often more easily maintained and the circulation of the

limb is said to be improved, particularly as regards the venous return. In general, abduction splints are unsatisfactory except for short

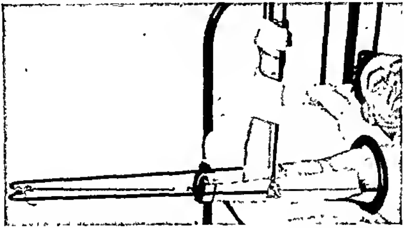


FIGURE 92
Continuous traction applied to the humerus in a Thomas's arm splint, fitted with a flexion-piece.

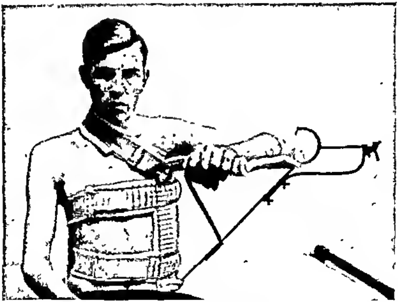


FIGURE 93
Continuous traction applied to the humerus in an abduction splint. A Kirschner wire is passed through the olecranon in line with the humerus. *The stirrup (Fig. 95) is tied with stretched rubber tubing to an extension attached to the bend of the splint.*

periods (p. 86), and should be reserved for cases where alignment cannot otherwise be obtained, or where continuous traction is required. An abduction plaster cast (Fig. 79) is a more satisfactory alternative, especially if the immobilization is likely to be prolonged.

Continuous traction is advisable in cases of persistent over-riding of the fragments, or in compound fractures where immobilization may be difficult to secure. *Thomas's arm splint* (Plate XXXI) can

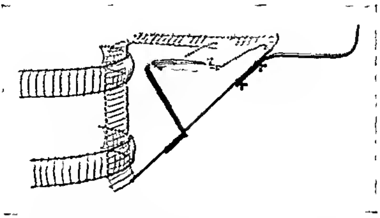


FIGURE 94

The abduction splint in skeleton form. It is made of Cramer's wire splinting supported by aluminium stays. The traction piece is detachable.

be used to provide traction, but the patient must be confined to bed during its use. The limb should be treated with the elbow flexed, as otherwise stiffness of the joint is liable to result: for this purpose a flexion piece should be attached to the splint. Skin traction may

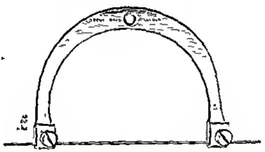


FIGURE 95

Specially light stirrup for holding Kirschner wire—for use when traction is applied to the olecranon.

(*Made for the author by Messrs. Down Bros*)

be used, but the upper arm alone provides a somewhat inadequate hold for the strapping, and skeletal traction applied to the olecranon process is probably more satisfactory. This is carried out by a Kirschner wire held by a specially light stirrup (Fig. 95). If ambulant treatment can be considered, it is better to apply the traction in an abduction splint. The details of this method are well illustrated in Fig. 93, and require no further description.

AFTER-TREATMENT IN FRACTURES OF THE HUMERUS

Fractures of the upper end and shaft of the humerus differ somewhat from fractures in other situations in regard to after-treatment, owing to the liability to subsequent stiffness of the shoulder joint. Immobilization, especially in old people, should be as curtailed as possible, even at the expense of some re-displacement of the fragments. Massage together with elbow and finger movements should be employed from the outset, and *active* movements of the shoulder should be commenced after a week or ten days.

Treatment in Abduction.—Sometimes prolonged immobilization may be required, as in cases of fracture of the shaft of the humerus with delayed union. It is then most essential that the abducted position should be maintained, for the muscles controlling the shoulder joint are thereby placed in a position of mid-tension, and wasting is minimized. If adhesions should form, the joint will be in a position in which the least disability will result. Immobilization in this position is also indicated in fracture of the greater tuberosity, and in rupture of the supra-spinatus tendon (p. 77). *Support* to the arm (but not necessarily immobilization) in the abducted position is indicated in all shoulder and upper arm injuries, where a disabling degree of abduction weakness persists in spite of treatment by massage and physio-therapy.

Optimum position of the arm.—This varies according to the injury. For fractures of the greater tuberosity and rupture of the supra-spinatus tendon, the arm should be abducted to 90 degrees, and equally full abduction should be employed when a cast is applied in the treatment of weakness of the abductor muscles. For fractures of the humeral shaft, abduction to 70 degrees is considered adequate, but the optimum position *will vary* in each individual case, according to the site of the fracture, and to any displacement which requires to be corrected. The shoulder joint should be in 30 to 40 degrees of forward flexion, and the humerus should be laterally rotated so that the forearm lies at an angle of 10 to 15 degrees above the horizontal. The elbow should be at a right angle. *These requirements are usually satisfied if the arm is placed so that the hand lies 12 to 14 inches directly in front of the ear.*

The choice in treatment lies between an abduction splint or frame and a plaster cast.

Abduction splint.—In cases where *immobilization* of the shoulder joint or humerus is required, abduction splints in general must be regarded as unsatisfactory, owing to the great difficulty of securing the splint firmly in position against the side of the trunk. It is useless to rely on the arrangement of straps and buckles supplied with the splint as the sole means of fixation. In addition, "at least ten or a dozen wide bandages must be used; they must be hitched under

every available screw, nut and bar, and passed over both shoulders" (Watson Jones). Constant supervision and regular adjustment are required. However carefully applied, and however heroically worn (for an abduction splint is always cordially disliked by the patient), there is an unavoidable tendency for slipping to occur, so that the immobilization is far from absolute, and re-displacement is common. *For continuous traction*, an abduction splint is excellent (Fig. 93). As long as traction is maintained, there is not the same necessity for complete immobilization, and such treatment is usually of relatively short duration. *For simple support of the arm*, an abduction splint is effective, and has the advantage that it can be removed to allow active movement and physio-therapy.

Abduction splints may be of the fixed type, or there may be provision for varying the position in which the shoulder and elbow joints are placed.

Abduction plaster cast.—When applied for the immobilization of the humerus or shoulder joint, a plaster cast is incomparably more satisfactory than any form of abduction splint. When properly applied, slipping cannot occur, so that no special supervision is required, and the fixation remains absolute. In addition, a plaster cast is usually much more contentedly tolerated than an abduction splint, the straps and bandages of which, together with the repeated adjustments required, constitute a continual irritation.

The cast is applied with the patient sitting on a stool, and resting his hand in the position described on some fixed object such as an adjustable stand. An assistant supports the elbow at the required degree of abduction. The cast should extend downwards on the trunk, so that it lies against the iliac crest on the affected side. It should be carefully padded, especially over the upper surface of the shoulder, and should include the hand as far as the middle of the palm, maintaining moderate dorsi-flexion at the wrist joint. *The fingers must be left with a complete range of movement.*

As the plaster cast has to support the entire weight of the arm, it must be *strongly* reinforced, or cracking is liable to occur within a very short time. A metal strip shaped to lie entirely within the cast is vastly preferable to any form of strut passing directly from the elbow to the iliac region, as with the former it is possible for all clothes to be worn in a normal manner—a boon which is very greatly appreciated by the patient. The strain, however, is so considerable that the metal, unless it is of unusual thickness, gradually becomes increasingly bent at the axilla. Alternatively, if tempered metal is used, slight "whip" movement may occur. In either case cracking of the plaster cast will rapidly result. A relatively thin strip of metal, however, is quite adequate for reinforcing the cast, if it is bent in the special manner shown in Fig. 96. The size of metal strip suggested is that in common use for "walking irons" (p. 231), *i.e.* $\frac{3}{4}$ inch by $\frac{1}{8}$ inch

mild steel bar: indeed a "walking iron" can be used very suitably for the purpose, as its length (24 to 28 in.) is usually adequate. Two bends are made in the iron at the junction of its thirds. The axillary bend (*A* in Fig. 96) is of paramount importance as it takes most of the strain. With the metal described, an ordinary bend "on the flat" at this point is useless, as it can never give sufficient rigidity. *It is essential that this bend should be "on the edge."* As the iron requires to be heated red hot for the purpose, it is advisable that this should be done by an instrument maker or in the hospital workshop. Many such bends have been successfully made by heating the iron on a gas ring, and by hammering it on the theatre floor, but this procedure

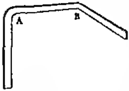


FIGURE 96

Metal strip (as used for "walking iron") specially bent for reinforcing an abduction plaster cast. At *A* the metal is bent *edgeways*.

FIGURE 97

Abduction cast, with plaster cut away to allow movement at the shoulder and elbow joints. A bridge of plaster is left over the shoulder. The cast must be strongly reinforced (Fig. 96).

cannot be officially recommended! The elbow bend (*B in* Fig. 96) is a bend "on the flat"; it is simply made with a spanner. It will

be seen that at both shoulder and elbow regions, the strain of gravity is taken "edgeways" on the metal; no give is possible, and the reinforcement is absolutely rigid. The care expended over such details is amply repaid later, for the cast will be found to last almost indefinitely.

Active movement in an abduction plaster.—It is often desirable that the patient who has been wearing an abduction plaster should carry out active exercises of the abductor muscles, before these are stretched by allowing the arm to hang by the side. Active movements in the direction of further abduction and of moderate flexion and extension may easily be carried out if a segment of plaster is removed from the entire upper surface of the abducted limb. As muscle tone returns, the patient can raise his arm completely out of the cast (Fig. 97); he can exercise the shoulder in all directions, except that he cannot drop the arm to his side. Full elbow movement is also possible. In addition massage and physio-therapy can be employed.

The plaster cast is of course considerably weakened by this procedure, and is entirely dependent for rigidity on the method of reinforcement employed. A single metal bar, bent in the manner described (Fig. 96), has been found to be quite satisfactory. A plaster cast of this description, applied in a case of axillary nerve paralysis, was worn continuously for ten months. At the end of this time, when functional recovery was complete, the cast was still perfectly rigid.

IX

THE ELBOW REGION

SUPRA-CONDYLAR FRACTURES

SUPRA-CONDYLAR fractures of the humerus most commonly occur in children. The fracture is situated about an inch above the lower end of the bone, and may be either transverse or oblique. In the typical fracture which results from a fall on the hand with the elbow flexed, the displacement is characteristic. The small distal fragment with the elbow joint is usually displaced backwards, and is further tilted by the weight of the forearm, and

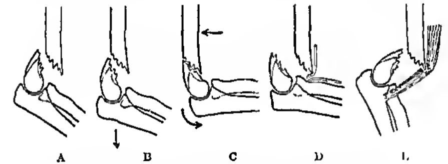


FIGURE 98

A.—The displacement typically found in a supra-condylar fracture.
B.—} Method of reduction. Traction is applied to the *flexed* elbow in the long
C.—} axis of the body, *before* the backward displacement is corrected.
D.—Effect of flexion of the elbow without preliminary traction; the displacement is unreduced and vessels may be nipped between the fragments.
E.—Extension of the elbow may lead to laceration of the brachialis muscle.

by the action of the triceps muscle. In addition, some lateral deviation or tilting may be present. If the break is an oblique one, the obliquity extends downwards and forwards from the upper border of the olecranon fossa, and the sharp edge of the upper fragment may be palpated in the anti-cubital region. (Fig. 98 A.)

Reduction.—*This should be carried out without delay,* as the swelling will increase as long as displacement remains unreduced. A general anaesthetic is required. The method of reduction is illustrated in Fig. 99. Keeping the forearm in a position of approximately right-angled flexion and *in pronation,* the surgeon grasps the elbow and applies traction in the long axis of the body, his other hand being used to steady the upper arm. The elbow is then pulled forwards, and the forearm is further flexed. It is most important that full flexion of the elbow should not be carried out without preliminary traction, as this alone will not reduce the deformity,

and vessels and nerves are liable to be nipped between the bony fragments (Fig. 98 D). Traction in extension is unnecessary, and may lead to tearing of the fibres of the brachialis muscle by the sharp edge of the upper fragment (Fig. 98 E). Any lateral displacement or

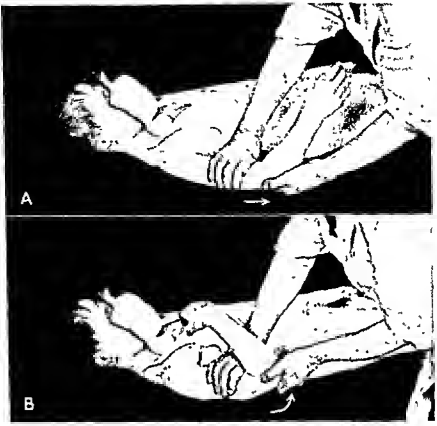


FIGURE 99
The reduction of a supra-condylar fracture.

tilting must also be corrected. Where possible, the reduction should be confirmed by radiographs taken while the patient is still under the anaesthetic, *so that further manipulations may be carried out if required.*

If excessive swelling is present, as in cases seen some time after the injury, the arm may be suspended for 24 to 48 hours, to allow the swelling to subside. Partial or complete reduction of the deformity may then occur without further manipulation (Fig. 100).

Immobilization.—If flexion of the elbow is maintained, the fragments will usually be held in satisfactory alignment, as the stretched triceps muscle forms a natural posterior splint. Various methods are in use. Of these, the simplest is a *collar-and-cuff* bandage (Fig. 83). *Adhesive strapping* may also be used; this is passed round the upper arm and forearm in the manner shown in Fig. 101. It should be "guarded" by strips of gauze (Fig. 102), as it passes round the dorsal surface of the arm, to prevent excoriation of the skin. *A dorsal*

plaster splint is an additional safeguard; it prevents lateral displacement and protects the tender elbow region from knocks.

The degree of flexion required.—Where possible, the elbow should be flexed through at least 90 degrees. From a purely mechanical viewpoint

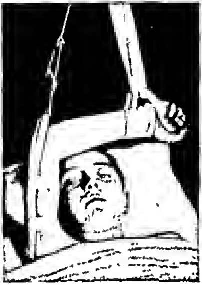


FIGURE 100

Method of suspending the arm in treatment of supra-condylar fracture; advised when excessive swelling is present. If the strapping is applied and the suspension carried out as shown, spontaneous reduction may occur. (The strapping should be further secured with a bandage.)

FIGURE 101

Supra-condylar fracture. Method of maintaining the flexed position by means of adhesive strapping. Note how the strapping is "guarded" (Fig. 102) as it passes over the dorsal surface of the upper arm. The wrist should be supported by a "collar-and-cuff" sling. (Omitted for clearness.)

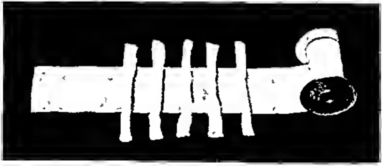


FIGURE 102

Adhesive strapping "guarded" by strips of gauze laid across it. This will diminish the likelihood of excoriation of the skin being produced.

the flexion should be as acute as possible, in order to maintain the position of the fragments, but due regard must be paid to the amount of swelling present, and the utmost care must be taken to ensure that the circulation of the forearm is not impeded. In general,

however, circulatory disturbance is uncommon, and if present, is more likely to be due to imperfect reduction, than to a hyper-flexed position.

After-treatment.—The circulation is carefully watched; the radial pulse must always be palpable, and there should be no swelling or

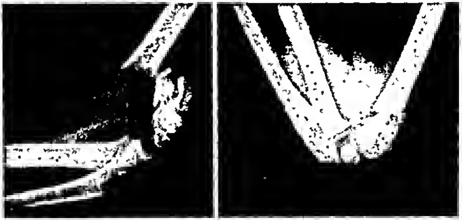


FIGURE 103

Radiograph (lateral view) of supra condylar fracture with typical displacement—before and after reduction.

(*Mr. R. I. Stirling's case.*)

congestion of the hand. If such signs are present, the amount of flexion must immediately be reduced.

The flexed position should be maintained undisturbed for 2 to 3 weeks, but movements of the fingers and shoulder should be carried out from the first. Thereafter, *active* movements of the elbow are gradually commenced; the forearm is supported in a sling which is lowered a little each day, and movements are allowed within the confines of the sling. Passive movements and massage are contra-indicated, as they may give rise to exuberant callus formation and possibly to ossification in the brachialis muscle.

Fractures with anterior displacement.—These fractures, which are relatively uncommon, are due to a fall on the elbow or to hyper-extension. The situation of the fracture is similar to that described above, but if oblique, the obliquity will usually be in the opposite direction. The lower fragment with the forearm bones is displaced *forwards* on the humerus, and the lower edge of the upper fragment underlies or may pierce the skin above the olecranon (Fig. 104).

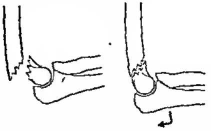


FIGURE 104

Supra-condylar fracture with *anterior* displacement; method of reduction.

For the reduction of such fractures, traction is applied in the manner already described, but the elbow region is thereafter pushed *backwards*, and subsequent immobilization

is carried out *in not more than right-angled flexion.* A dorsal plaster slab is used; it should extend from the upper third of the arm to the knuckles, and must be firmly bandaged in position, as re-displacement is common.

Watson Jones maintains that reduction is stable only if the elbow is immobilized *in full extension*, and advises three weeks' fixation in a dorsal plaster splint. Swelling of the hand is a troublesome complication, especially in ambulant patients, but recovery of full flexion at the elbow is not unduly delayed. The method may be reserved for cases where re-displacement has occurred with the elbow in the flexed position.

INTER-CONDYLAR FRACTURES

These fractures are more common in adults, and are due to a heavy fall or blow on the elbow. The line of fracture is usually T- or

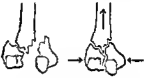


FIGURE 105

Inter-condylar fracture with typical displacement. Arrows indicate method of reduction.

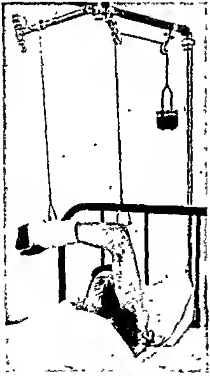


FIGURE 106

FIGURE 106

Continuous traction applied to an inter-condylar fracture, by means of a Kirschner wire passed through the olecranon. 5 to 8 lbs. weight is attached. The wrist and hand are supported by a light plaster cast. After a short period of traction, fresh radiographs are taken, and further compression of the fragments is carried out as required. The elbow is then enclosed in plaster, while traction is maintained.

Y-shaped; there is a more or less transverse supra-condylar fracture, and in addition, the lower fragment is split longitudinally into the joint (Fig. 105). Considerable displacement is frequently present;

the two condylar fragments are carried forwards, and they are often widely separated, the upper fragment being driven between them. A variable degree of comminution of the fragments occurs, and the fracture may often be compound.

Reduction of the fracture is a matter of considerable difficulty, and it may be impossible to obtain accurate reposition of the fragments. Operative exposure and mechanical fixation are frequently advised, but the results as a whole are disappointing, and compare unfavourably with those obtained by conservative treatment. Reasonably satisfactory reduction can usually be effected by manipulation. *Traction* is applied in the line of the humerus, with the forearm flexed to a right angle (Fig. 88), and an attempt is made to mould the condylar fragments into position, by side-to-side compression of the elbow region. A dorsal plaster slab is then applied, but immobilization should be completed by converting it, as soon as it has set, into a *circular cast.* This should be split throughout its entire length, and may with advantage be suspended for the first 24 to 48 hours (Fig. 115).

Alternatively, and particularly if the fracture is compound, continuous traction may be employed. This is most successfully carried out by the method shown in Fig. 106. A Kirschner wire is passed through the olecranon, at a point in line with the humerus, and traction is applied in a vertical direction by 5 to 8 lbs. weight. The forearm is maintained in moderate pronation, with the elbow at a right angle. As soon as the position of the fragments is judged to be satisfactory, the elbow is enclosed in plaster, while continuous traction is maintained.

DISLOCATION OF THE ELBOW JOINT

Dislocation of the elbow joint occurs mainly in adults, and, like supra-condylar fracture in children, results from a fall on the hand when the elbow is flexed. The forearm bones are driven backwards, and the humeral condyles over-ride the coronoid process of the ulna, so that the brachialis muscle is either grossly stretched or partially avulsed from its insertion. A chip fracture of the coronoid process is often present. The elbow is held rigidly in a semi-flexed position, and the deformity of the joint region is characteristic (Fig. 108 A).

Reduction.—In recent cases, this offers no difficulty, although an anaesthetic is usually required. No attempt should be made to extend the elbow, as this will cause further damage to the already stretched brachialis muscle (Fig. 107 B), and *may also injure the vessels* and nerves of the cubital fossa. Traction is applied to the forearm *in the axis in which it lies,* while counter-pressure is exerted against the upper arm (Fig. 108 B). No great force is required, and the bones usually slip back into place without difficulty.

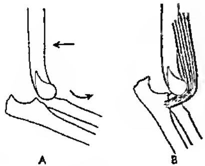


FIGURE 107

A.—Typical displacement in posterior dislocation of the elbow. Arrows indicate method of reduction.
B.—Extension of the joint before reduction may cause tearing of brachialis muscle.

After-treatment.—Owing to the danger of ossification in the brachialis muscle (myositis ossificans), complete rest to the elbow joint is essential for at least three weeks. During this time the wrist is supported in a "collar-and-cuff" sling (Fig. 83). A dorsal plaster splint may be applied; this is valuable in ensuring complete immobilization of the elbow joint, and at the same time it allows active movements of the hand and shoulder joint to be carried out with

FIGURE 108

A.—Dislocation of the elbow, with typical deformity produced by backward displacement of the forearm bones. Note undue prominence of olecranon and hollowing behind epicondyles.
B.—Method of reduction, by traction applied in the long axis of the forearm.

FIGURE 109

Manipulative treatment of "tennis elbow."

A.—The wrist is fully flexed with the forearm in a position of extreme pronation.
B.—While the wrist *is held firmly in this position*, the elbow is *sharply* extended to its fullest extent. In successful cases, a sharp click may be elicited, when the manipulation should be followed by complete relief of symptoms.

greater freedom. After three or four weeks, active movements of the elbow are instituted gradually. Gentle massage is then permissible, but passive stretching must on no account be attempted, as this is a frequent cause of myositis ossificans.

"TENNIS ELBOW"

The clinical features of this condition, which is by no means confined to tennis players, consist of pain in the region of the lateral epicondyle or radio-humeral joint. The pain is brought on by movements of supination combined with dorsi-flexion of the wrist. Various theories are put forward as to its causation. Of these, the most acceptable suggests that the condition is due to a partial tearing *of the aponeurotic fibres of the common extensor origin from their* attachment to the lateral epicondyle, or to elevation of the periosteum, with the subsequent formation of adhesions.

Manipulation.—This frequently brings about complete relief of symptoms. It may act either by breaking down adhesions, or by completing the rupture of fibres which are only partially torn and are so giving rise to pain. The technique of manipulation is illustrated in Figs. 109 A and B.

1844

X

FRACTURES OF THE FOREARM

FOR the successful reduction of fractures of the bones of the forearm, it is necessary to understand the mechanism of the displacements which may exist. This is somewhat complicated owing to the very varied relationship of the two bones to one another, throughout the full range of movement between pronation and supination. The deformities which are encountered depend mainly on the existence of this type of movement, and are best considered in terms of the displacement of the fragments of the radius, for it is this bone which rotates around the relatively fixed ulna. Fractures of the ulna alone, therefore, show little or no displacement, but in fractures of the radius or of both bones, considerable deformity may be present.

FRACTURES OF BOTH BONES

In fractures of both radius and ulna, three displacements require to be considered—over-riding of the fragments, rotational deformity, and displacement towards the interosseous space.

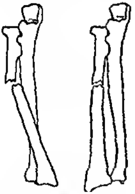


FIGURE 110

Fracture of upper third of radius. Rotational deformity corrected by placing hand in full supination.

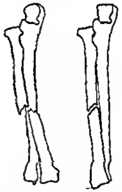


FIGURE 111

Fracture of middle of shaft of radius. Deformity corrected by placing hand in mid-position.

Over-riding of the fragments is due simply to the pull of the longitudinal muscles, and can be corrected by traction applied in the line of the forearm.

Rotational deformity.—This is determined by the position occupied by the radial fragments. The lower fragment, together with the hand, usually tends to fall into a position of pronation, as the pronator

and flexor muscles are stronger than the supinators and extensors (Böhler). The position of the upper fragment depends upon the level of the fracture. If this is above the insertion of the pronator teres, the fragment is supinated by the action of the supinator and biceps (Fig. 110). If the fracture is below the pronator teres insertion the upper fragment has both pronator and supinator muscles inserted into it, and lies therefore in mid-position (Fig. 111).

Displacement towards the interosseous space.—Such displacement usually affects the lower radial fragment, and may be due to the

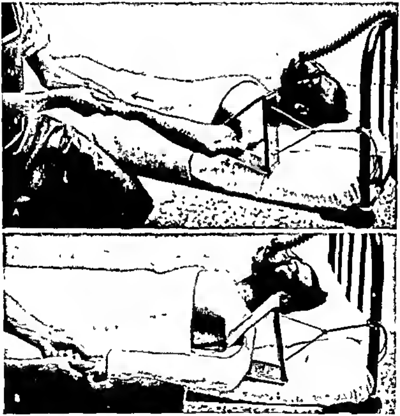


FIGURE 112

Fracture of the forearm bones.

A.—Method of applying traction in the line of the forearm.

B.—Application of dorsal plaster splint, while traction is maintained.

The special sling (shown separately in Fig. 87) is particularly useful, as it leaves two thirds of the circumference of the upper arm free for the application of the plaster splint.

combined pull of the pronator and supinator muscles acting upon it. The nature of the fracturing force can also be a contributory cause.

Reduction.—Reduction must be directed mainly towards replacing

the *radial* fragments in their normal alignment, by traction applied with the arm in an appropriate position of rotation. The ulnar fragments will then usually be found to be in good position.

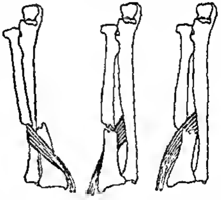
Traction is applied in the line of the forearm by an assistant who holds the thumb in one hand, and the first two or three fingers in the other. Counter-traction is provided by a sling which is passed round the upper arm above the elbow and is tied to the top of the bed, or to a hook in the wall (Fig. 112 A). It is essential that the traction should be kept up for several minutes, in order that over-riding of the fragments may be overcome. If the patient's fingers are slippery, they may be painted with mastisol or covered with adhesive strapping.

The position of the arm will depend upon the site of fracture, as in all cases the lower fragment must be brought into line with the less controllable upper one.

In fractures of the upper third of the radius, the forearm should be held in full supination, as the upper fragment will lie in this position (Fig. 110).

In fractures of the middle third, the mid-position is adopted (Fig. 111).

In fractures of the lower third, there is a special tendency for the lower fragment of the radius to be displaced towards the ulna. This may be due to the pull of the pronator quadratus muscle, or, as Böhler suggests, it may be caused by the action of the abductor pollicis longus, and extensor pollicis brevis. With the hand in the pronated position, which is customary after such fractures, these muscles are stretched round the lateral side of the lower radial fragment, and tend to press it towards the ulna (Fig. 113). It is suggested therefore that the position of *full supination* should be employed for the reduction of this deformity. In addition, strong traction is applied—especially to the thumb.



A B C

FIGURE 113

A.—Fracture of lower third of radius, with typical displacement.
B.—Displacement reduced by full supination of hand.
C.—*Reduction impossible owing to interposition of muscle.*

Local anaesthesia may be used for the reduction; 10 to 20 c.c. of 2 per cent. novocaine are injected between the fragments. Radiographs should be taken immediately after reduction, and it is an additional advantage if the manipulations can be carried out under screen examination.

In the majority of cases of fracture of the radius and ulna, no

great difficulty is experienced in correcting the over-riding and rotational deformity, if traction is applied with the forearm in the appropriate position. In some cases, however, the displacement of a fragment towards the interosseous space defies all efforts at manipulative reduction; this may be due to the inter-position of muscle between the fractured surfaces (Fig. 113 C). In view of the disability which will result if cross-union is allowed to occur, open operation should be undertaken.

FIGURE 114

U-shaped plaster splint for fractures of the forearm.

Immobilization.—While the traction is maintained, *a dorsal plaster slab* is applied extending from the middle of the upper arm to the knuckles (Fig. 112 B). The part covering the forearm is at once converted into *a complete circular cast*, which may be padded over the flexor aspect. *The traction must be continued* until the plaster has set, after which the sling is removed and the circular cast is extended up on to the upper arm, the elbow being well padded anteriorly. The plaster includes the hand, but the fingers should be *left with a complete range of movement.* While the cast is drying, it should be flattened antero-posteriorly over the forearm. It will then have an oval rather than a round shape, so that the bones will not be pressed towards one another. The cast should also be moulded to restore the normal anterior concavity of the forearm bones. For fractures in the lower third, a *U-shaped cast* may be employed (Fig. 114). This lies on the flexor and extensor aspects of the forearm, passing behind the elbow. It allows slight movement of the elbow joint, but adequately prevents movements of pronation and supination.

FIGURE 115

Method of suspending the arm after the application of a complete plaster cast. The cast is split by cutting it while it is wet over a strip of felt, which is shown. Note the support given to the hand by a band of plaster passing round the palm.

After-treatment.—A careful watch must be kept on the circulation, and at the first sign of obstruction, the cast should be split. It is a wise precaution, however, to do

this as routine (Fig. 131), and, where possible, to suspend it for the first 48 hours (Fig. 115).

Movements of the fingers are carried out from the outset, and these should be of a *purposeful* character (*see p.* 114). Shoulder exercises are also advisable, particularly in old people.

The cast should be retained for at least 6 to 8 weeks, and a much longer period of immobilization may be required, as delayed union is not uncommon. It must not be removed before there is radiological evidence of union, *and must not be cut down to below the elbow.* In such fractures, " a short forearm plaster is more dangerous than no plaster at all " (Watson Jones), as rotation strains at the fracture are actually increased. These strains give rise to absorption of callus, and non-union may result.

FRACTURE OF THE SHAFT OF THE RADIUS

In simple fractures of the radius, over-riding of the fragments will not occur, but rotational deformity and some displacement of the lower fragment towards the ulna may be present (Fig. 113). The treatment is on similar lines to that described for fractures of both bones.

Fracture of radius with dislocation of ulna.—A fracture of the lower third of the radius may be accompanied by a dislocation of the radio-ulnar joint, the head of the ulna being displaced medially. This complication is always suspected if the lower radial fragment shows any marked displacement towards the ulna, and particularly if over-riding is present.

The deformity is reduced by the application of strong traction to the thumb in the manner already described for fractures of both bones (Fig. 112). As the normal support of the ulna is lost, there is a great tendency to re-displacement, with deviation of the hand towards the radial side. The wrist should therefore be immobilized with the hand in full ulnar deviation. If displacement recurs, continuous traction should be applied to the thumb, as in the treatment of Bennett's fracture (*see p.* 120).

FRACTURE OF THE SHAFT OF THE ULNA

Fracture of the shaft of the ulna alone is usually due to a direct blow on the arm, and deformity is often slight or absent. Treatment consists in the application of a plaster splint or circular cast, *which includes the elbow*, and which must not be removed till union is firm. Fractures of the shaft of the ulna, particularly at the junction of the middle and lower thirds, have long been regarded as being prone to non-union, but it is now recognized that this is always due to inadequate immobilization (*e.g.* in a splint or cast which does not include the elbow), or to immobilization for too short a period.

Fracture of ulna with dislocation of radius.—This injury usually results from a direct blow on the back of the forearm, which fractures

FIGURE 116

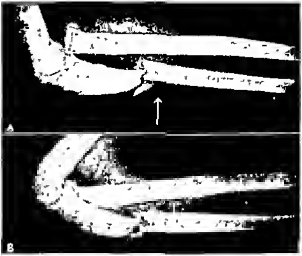


FIGURE 117

Fracture of upper third of shaft of ulna, with forward dislocation of head of radius Arrows show direction of fracturing force. Note indentation of ulnar border of forearm—a sign which, however, is often masked by swelling Radiographs—before and after reduction.

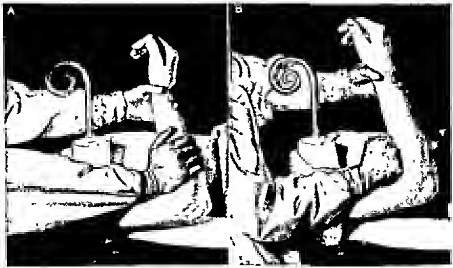


FIGURE 118

Method of reducing a forward dislocation of the head of the radius, and at the same time correcting the angulation of the ulna Counter-pressure in the axilla is provided by a lithotomy crutch, around which an entire flannel bandage has been wound

the ulna, and at the same time drives the upper end of the radius forwards (Figs. 116 and 117). Such a dislocation is always suspected in fractures of the upper part of the shaft of the ulna, particularly

if displacement is present. *An effective method of reduction is shown* in Fig. 118. If this is unsuccessful, strong traction must be applied to the forearm (Fig. 112), and, while the traction is maintained, an attempt is made to push the head of the radius backwards into position.

Immobilization is secured by means of a dorsal plaster splint. To prevent recurrence of the dislocation, the elbow is flexed to a *fairly acute angle*, but, in the presence of much swelling, care must be taken to ensure that the circulation is not impeded. As with other fractures of the forearm bones, the immobilization must be continued till union is firm.

"GREENSTICK" FRACTURES

"Greenstick" or incomplete fractures of the forearm occur in *young children, while the bones are still soft and bendable*. Both bones

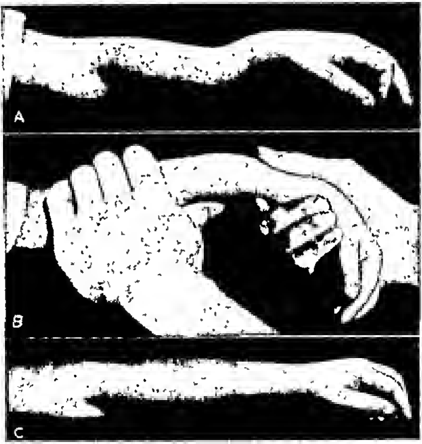


FIGURE 119

"Greenstick" fracture of the forearm. Note how the deformity is forcibly over-corrected.

are usually affected; in one the fracture may be complete. Displacement of the fragments is usually slight or absent, but in typical cases obvious angulation is present (Fig. 119 A).

Treatment.—Reduction must be carefully carried out. As a rule, it is not sufficient merely to straighten the forearm, as the bone on the concavity of the bend has been compressed, and the angulation tends to recur immediately. It is essential that the deformity should be *over-corrected*, and the forearm is bent until such over-correction is obvious (Fig. 119 B). For this, a surprising amount of force may be required, but sudden jerking movements are to be avoided. A sharp crack is sometimes elicited, and indicates that the partial fracture has been rendered complete. This occurs in about half the cases, and is regarded by some surgeons as an essential part of the reduction. The fracture remains sub-periosteal, so that no displacement should result.

Subsequent immobilization is secured by a dorsal plaster splint. This is usually made to extend from the knuckles to the middle of the upper arm, the elbow being flexed to a right angle. The splint is worn for three weeks. In cases where little mobility is present after reduction, it will suffice if the splint covers the hand and forearm alone.

XI

INJURIES ABOUT THE WRIST

COLLES'S FRACTURE

A COLLES'S fracture occurs at the lower end of the radius, about ¾-inch above the articular surface. The fracture is usually more or less transverse: normally it does not involve the articular surface, but sometimes secondary fracture lines may spread into the joint, and give rise to extensive comminution of the lower fragment. The styloid process of the ulna may also be torn off. A varying degree of impaction is usually present.

In a typical case, four displacements can be described, all of which may be well shown by the radiographs. In the antero-posterior

FIGURE 120

Colles's fracture with typical deformity.

view, the lower radial fragment is seen to be *displaced radially* and *rotated radially*, and, in the lateral view, it is *displaced dorsally* and *rotated dorsally* (Fig. 121). Of these displacements, the dorsal rotation or tilting is the most characteristic, and may be the only deformity found; it is easily missed in radiographs, as, owing to the impaction commonly present, there may be little obvious change in the outline of the bone. In deciding whether tilting has occurred, special attention should be paid to the plane of the lower articular surface of the radius, as seen in a lateral radiograph (Fig. 122). In the normal bone, this is not perpendicular to the axis of the shaft, but inclines at about 20 degrees towards the palmar side, *i.e.* it faces roughly in the direction of the metacarpal bone of the thumb. If this normal inclination is not present, backward tilting has occurred and its correction must be undertaken.

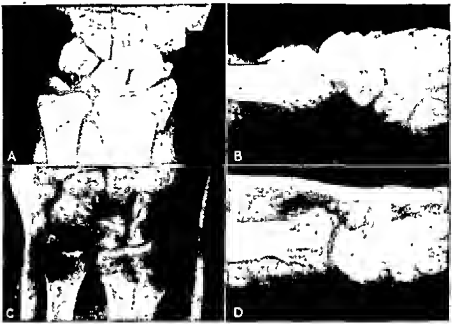


FIGURE 121

Colles's fracture.

A and B.—Before reduction C and D.—After reduction.
Note the four displacements described in the text.

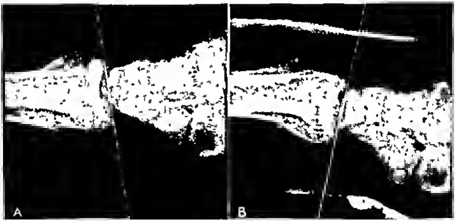


FIGURE 122

A.—Lateral radiograph of Colles's fracture (A-P view showed no displacement.) Note the dorsal tilting of the lower fragment, and that this may be missed, unless attention is paid to the plane of the articular surface.

B.—After reduction The normal inclination of the articular surface has been restored.

Reduction.—It is most important that any displacement however slight should be reduced. Backward tilting, if uncorrected, gives rise to permanent weakness of the wrist joint. Radial deviation, which

FIGURE 123

First stage in the reduction of a Colles's fracture. Disimpaction of the radial fragment by applying traction in the line of existing deformity.

may at first appear to be insignificant, and which may be masked by swelling, will later give rise to unsightly deformity.

An anaesthetic is always essential to satisfactory reduction. General anaesthesia is to be preferred, but, where facilities for such are not available, the injection of 10 to 15 c.c. of 2 per cent. novocaine into the fracture haematoma will be found to give a satisfactory anaesthesia.

The fracture should first be disimpacted by applying strong traction to the hand in the axis in which it lies, *i.e.* while the existing dorsal tilting of the radial fragment is maintained (Fig. 123). When the fragment has been completely freed in this way, it can be moved without difficulty over the fractured end of the radial shaft. The *dorsal displacement* is reduced by direct pressure between the two thenar eminences (Fig. 124 A). The lower fragment is pressed palmar-wards and into pronation, while pressure on the upper fragment is exerted in the opposite direction. The *radial displacement* is corrected by pressing the lower fragment very strongly towards the ulna (Fig. 124 B). As part of the first manipulation the wrist is strongly palmar-flexed, and as part of the second the hand is pressed into ulnar deviation.

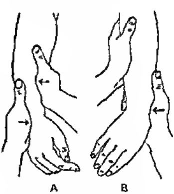


FIGURE 124

Reduction of displacement in a Colles's fracture. (*See text.*)

These two manipulations may be combined by the manoeuvre shown in Fig. 125, in which the surgeon places the forearm with its

ulnar border across his knee. With the ball of his thumb, he forcibly presses the lower radial fragment, first towards the ulna, and then

FIGURE 125
Alternative method of reducing a Colles's fracture. The radial fragment is pressed first towards the ulna, and then into pronation.

palmar-wards and into pronation. Both dorsal and radial displacements are thus corrected.

If much comminution of the lower fragment is present, strong traction should be applied to the hand—and especially to the thumb—

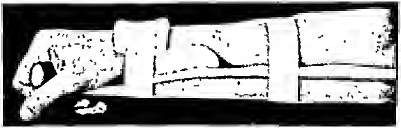
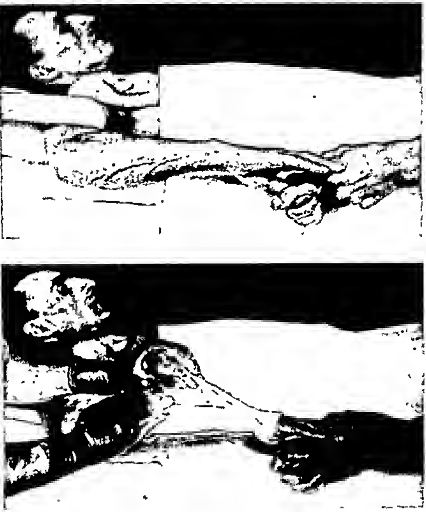


FIGURE 126
Carr's splint applied for Colles's fracture. The arrangement of the pads prevents *dorsal* displacement, but lateral movements of the wrist are not *adequately controlled, and radial displacement may recur.*

during the moulding of the fragments (Fig. 127). The traction must be maintained while plaster is being applied, and until setting has occurred.

Splints.—Many different types of splint have been employed, ranging from plain pieces of wood to splints which are moulded to

fit the contours of the wrist and hand. It must now be stated that these have little or no place in the modern treatment of Colles's fracture. As compared with a plaster cast, a splint is both ineffective and cumbersome; it provides little control of the hand in regard to lateral movement, so that its use involves a risk of recurrent radial



FIGURES 127 AND 128

Method of obtaining traction in Colles's fracture with comminution of lower fragment. A dorsal plaster slab is applied to the forearm while traction is maintained. Note the band of plaster carried round the palm.

deviation. In addition, a splint prevents active use of the hand and fingers during treatment (*see p.* 114). The use of splints is now advised only as a temporary measure, where plaster of Paris is not available. Carr's splint, and the method of its application, are shown in Fig. 126.

Plaster fixation.—A well-fitting plaster has very definite advantages over any other form of splint. The immobilization provided is much more effective, as the plaster can be carefully moulded to

maintain the position of the fragments, and in addition the fingers are left with a full range of movement.

Position of the wrist joint.—The wrist joint should be immobilized *in slight palmar-flexion, and with the hand in ulnar deviation.* A satisfactory degree of palmar-flexion is obtained if the dorsal surfaces of the hand and forearm are placed in a straight line. The reduction is more certainly maintained with a greater degree of palmar-flexion (Cotton-Loder), but fixation in this position prevents active use of the hand and fingers, and, if it is maintained for more than a few

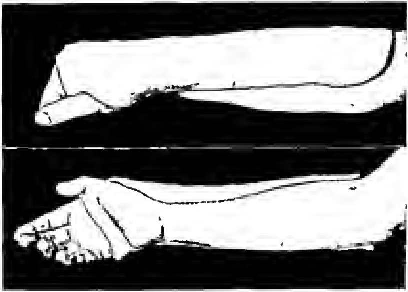


FIGURE 129

Plaster splint for a Colles's fracture. It should be secured to the forearm and wrist by a bandage, which (for the sake of clearness) is not shown. Note that the plaster covers the radial side of the wrist joint and the first metacarpal bone. The narrow band of plaster crossing the palm must not interfere with closure of the fist. (*See Fig.* 130.)

days, permanent stiffness is very liable to result. Dorsi-flexion must always be avoided, as it predisposes to a recurrence of the dorsal tilting of the lower fragment.

The plaster which extends from below the elbow to the knuckles should cover the first metacarpal bone and the tubercle of the scaphoid, in order to maintain the position of ulnar deviation. If this precaution is neglected, radial displacement is liable to recur. Either a plaster slab or a complete circular cast may be used.

A plaster slab (Fig. 129) is conveniently made from two 6-inch bandages. It is placed over the dorsum of the hand and forearm, but should cover the radial side of the wrist joint and the shaft of the first metacarpal bone. While it is still wet, the plaster slab is trimmed with scissors, so that its end follows the line of the meta-

carpal heads. The last two feet of plaster bandage should be reserved for the purpose of making three or four turns round the hand. Where the turns cross the palm, they are squeezed together to form a more or less rounded "rope." *This must lie proximal to the palmar creases, so that finger movements are unrestricted, and the hand can be closed to form a fist.* To ensure such freedom of movement, the plaster in the palm should be moulded, as soon as it has been applied, by full flexion of the metacarpo-phalangeal joints (Fig. 130 A and B). The

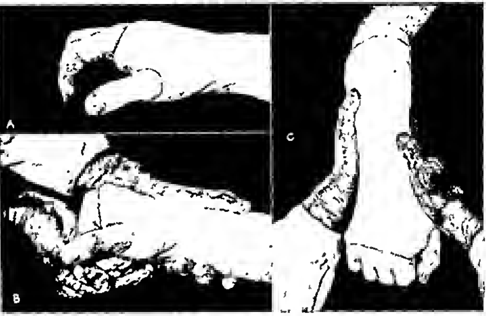


FIGURE 130

The moulding of a plaster cast for Colles's fracture.

A.—If the plaster bandages encircling the hand are left in this position, closure of the fist is prevented.
B.—While the plaster in the palm is still soft, it should be moulded by full flexion of the metacarpo-phalangeal joints.
C.—Moulding around the wrist, to prevent re-displacement. The radial fragment and carpus are pressed forwards and medially. Slight palmar-flexion and moderate ulnar deviation are obtained. *The pressure is kept up until the cast has hardened.*

plaster is secured to the forearm with a wet gauze bandage. While setting is taking place, it should be moulded carefully around the wrist region. The radial fragment and carpus are pressed forwards and medially (Fig. 130 C), and the pressure is maintained until hardening of the cast has occurred.

Immobilization by a plaster slab involves no risk of interference with the circulation, for the gauze bandage can be loosened at the first sign of constriction. For this reason it is preferable to a circular cast during the first few days after reduction. It is less durable however, and, in the later stages of treatment when the patient is expected to carry out useful work, it may give inadequate protection.

A circular cast.—The plaster slab applied after reduction may

be converted into or replaced by a circular cast, at any time after the first few days, when swelling has subsided. As before, care must be taken that any plaster in the palm of the hand does not interfere with finger movements (Fig. 130). A circular cast may be applied from the outset; this is indicated where there is extensive comminution of the radial fragment. In such cases considerable swelling may be present, so that a careful watch must be kept on the circulation. A padded plaster should *not* be applied; a moderate amount of padding is no safeguard against constriction, and, if there is sufficient padding to allow for swelling, the immobilization will be inadequate. *It is much better to use an unpadded cast, and to split it in the manner shown in Fig. 131.* A split cast of this type fits closely, but will give considerably in the presence of swelling. Alternatively, it can easily be prized open by a nurse. The precaution of

FIGURE 131

Plaster cast for a Colles's fracture When applied immediately after reduction, the cast should be split as shown A strip of felt or rolled up lint is laid along the limb before plaster is applied, and the cast, while it is still wet, is easily cut through in this line.

splitting the plaster cast may in many cases be unnecessary, but it does not interfere with the immobilization, and, like Moynihan's "hypnotic sutures," it enables the operator to sleep more peacefully.

The position of the fragments should be checked by radiographic examination, as soon as the plaster has been applied. In deciding whether reduction is complete, special attention must again be paid to the plane of the lower articular surface of the radius, as seen in a lateral radiograph (Fig. 122). If the normal inclination is not restored, a further attempt at reduction should be made.

After-treatment.—With the type of plaster fixation described, the fingers can be moved throughout the normal range, and, by full flexion of the metacarpo-phalangeal joints, the hand can be closed to form a fist. This should be demonstrated to the patient, who is instructed that *without delay* he must exercise his fingers to the fullest extent. As soon as he is able, he should use his hand for all possible purposes—using a knife and fork, lifting a cup or glass, writing, etc. For female patients, knitting is an ideal exercise.

Böhler has pointed out that joint stiffness after fracture is rarely due to causes within the joint, but rather to disuse atrophy of the muscles acting on the joint, and to adhesions within their sheaths. *Finger movements can do much more than preserve the mobility of the fingers*, for, if they are purposeful and co-ordinated, they are accompanied by contraction of the synergist muscles acting on the wrist joint. If such activity can be maintained during the immobilization of the joint, subsequent stiffness will be minimized. *For this, however, it is essential that the movements should be purposeful—mere aimless twiddling of the fingers is useless!*

After a week or ten days, fresh radiographs should be taken to ensure that redisplacement has not occurred. If the initial plaster cast has become loose, it should be renewed.

Movements of pronation and supination will be recovered gradually after the first week, when the patient will find himself able to turn door handles, etc.

The plaster slab is retained for four to five weeks. If the patient has obeyed instructions to use the hand, no stiffness should result, and massage will usually be unnecessary.

A sling should be worn for the first week, but this is merely to prevent gravitational oedema, which would occur if the hand were allowed to hang by the side; it is only employed in the intervals when the hand is not being used.

FRACTURE OF THE SCAPHOID (NAVICULAR)

The scaphoid is most frequently fractured in its narrow central part. The fracture may be no more than the slightest crack in the cancellous bone, and is very liable to be missed on radiographic examination unless films are taken in three planes. An oblique view of the carpus will frequently show up a fracture which cannot be demonstrated in antero-posterior and lateral views. Furthermore, a small crack may be quite undetectable in radiographs taken within a few days of the injury; it may only become apparent when local decalcification has occurred, as the result of shearing strains due to movements of the wrist joint. It is advised therefore that, where the clinical diagnosis of a scaphoid fracture is not supported by the radiographs, the examination should be repeated after an interval of two to three weeks.

The importance of what may seem to be a trivial injury lies in the fact that, if the wrist is not immobilized, progressive decalcification takes place, with the formation of a cystic-like gap between the fragments. In untreated cases considerable disability results from weakened grip and from constant aching pain in the wrist.

Immobilization.—The treatment consists in complete immobilization of the wrist joint in a position of *moderate dorsi-flexion*. Not

only must the immobilization be absolute—it must be prolonged. The blood supply of the fragments is poor, and union is always slow. Either a plaster cast, or a specially made splint may be employed.

Plaster fixation.—A closely-fitting unpadded plaster cast should be applied, extending from the knuckles to the upper third of the forearm. It should cover the palm of the hand (Fig. 132), but care

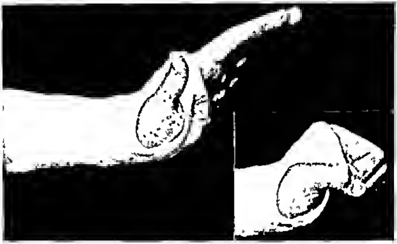


FIGURE 132
Plaster cast advised for treatment of fractured scaphoid.

should be taken that it does not extend beyond the transverse creases, and so does not interfere with full flexion of the fingers at the metacarpo-phalangeal joints (Fig. 130 A and B). Some surgeons advise that the cast should be moulded around the metacarpal bone of the thumb, but *this is probably unnecessary* if the plaster encircles the hand in the manner shown. It is at the wrist joint that immobilization is so essential, and the type of cast described effectively prevents all movements of this joint.

The patient can usually return to light work while wearing the plaster cast. *He should be instructed that he must have it renewed without delay, should it crack or become soft.* Such instructions are of the greatest importance. All too frequently, a patient returns wearing a plaster cast, which, for several days or even for a week or two, has been completely useless. If movement is allowed before union is firm, absorption of callus will result, and many weeks of immobilization may be wasted.

Special splint.—To avoid certain disadvantages of plaster fixation (p. 118), a special splint has been devised. This consists of a framework to which is attached an adjustable band for encircling the hand. The framework, which is made of light metal, is applied to the dorsum of the forearm and hand. It is incorporated in a plaster cast, which extends only as far as the level of the wrist joint. The encircling band

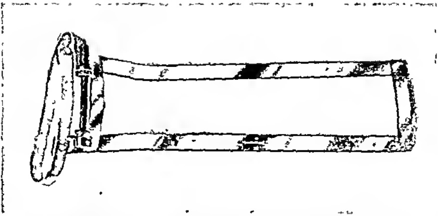


FIGURE 133

Special splint for the treatment of scaphoid fractures.

(Made for the author by Down Bros. Ltd., London.)

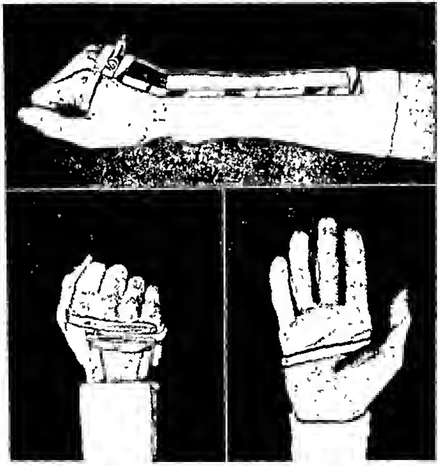


FIGURE 134

Application of scaphoid splint.

The framework of the splint is shaped to fit the plaster cast, and so that it lies comfortably and evenly against the back of the hand in the required position of dorsiflexion. *It is then incorporated in the cast. The aluminium band lies proximal to the palmar creases, so that movements of the fingers are unrestricted.*

is made of soft aluminium, and is easily moulded round the hand by digital pressure. It is adjustable by means of a bolt, which can be turned with a small coin.

The standard splint, as supplied by the manufacturers,[1] is designed so that the circumference of the band can be varied between 8 inches and 9½ inches, *i.e.* it will fit the hand of most adult male patients. (Other sizes require to be specially ordered.) The framework is shaped to hold the hand in moderate dorsi-flexion, but, being of soft metal, it can be bent easily with a spanner to suit individual requirements.

The splint, together with the method of application, is shown in Figs. 133 and 134. A light plaster cast, composed of one 4-inch bandage, is first applied extending down to the level of the wrist joint. The framework of the splint is bent so that it lies *comfortably and evenly* against the skin of the back of the hand in the required position of dorsi-flexion, and it should also be shaped so that it lies closely against the surface of the plaster cast (Fig. 134). It is then incorporated in the cast with a second plaster bandage. Finally, the aluminium band is moulded by digital compression to the contour of the hand, and is tightened by means of the bolt. With careful attention to the moulding of the splint, and with the patient's co-operation in indicating areas of pressure, absolute fixation of the wrist joint is obtained, without any discomfort being felt. The band lies proximal to the transverse creases of the palm, so that flexion of the fingers is unrestricted. The patient is instructed that the band should be kept as tight as can be comfortably borne. The size of the hand may vary considerably with the temperature of the surroundings, and adjustments should be made accordingly.

It is claimed that this splint has certain advantages over a plaster cast. Even when every care is exercised, the effective life of a wrist plaster does not usually exceed six weeks; it is likely to be much shorter if active work is carried out with the hand, or if the plaster becomes moist from sweating of the palm or as the result of careless washing of the fingers. If, as is frequently the case, the period of immobilization required extends into several months, a succession of plaster casts must necessarily be applied. Before a defective cast can be renewed, some movement at the wrist joint is usually inevitable, and there is likely to be a consequent retrogression in the healing process. The splint on the other hand lasts indefinitely, and the plaster cast which secures it to the forearm should not require renewal for several months. With the co-operation of the patient in adjusting the splint to suit the variations in size of the hand caused by temperature changes, more complete immobilization is obtained. When carefully applied, the splint is no more uncomfortable than a plaster cast; it interferes less with active use of the hand, and the fact that

[1] *Messrs. Down Bros., London.*

the plaster does not extend below the wrist allows the whole hand to be washed. The framework of the splint does not interfere with X-ray examination of the fracture.

Duration of treatment.—Six to eight weeks is given as the minimum period during which complete immobilization must be maintained, but no movement must be allowed until there is radiological evidence of union. X-ray examination should be carried out at monthly intervals. If the plaster cast is firm and tight-fitting, it should not be removed for the purpose of examination, as radiographs taken through the plaster may show conclusively that union is not complete. Such radiographs, however, cannot be accepted as evidence of *union*, and the examination should therefore be repeated after removal of the cast. If union is then shown to be incomplete, further fixation must immediately be carried out. No time limit can be given for the duration of treatment, but union should not be despaired of until nine months or a year have elapsed—and then only if the fixation has been absolute.

As a test of cure, a further X-ray examination should be made three weeks after removal of the cast. If union has been incomplete, absorption of the new bone occurs, and the fracture line again becomes apparent.

Cases with non-union.—The diagnosis of " non-union " in scaphoid fractures is a matter of controversy. Many such fractures will heal if the immobilization is sufficiently prolonged. Established non-union is indicated by the occurrence of sclerosis in the bone adjacent to the fracture. In such cases, multiple drilling of the fragments or the insertion of a bone graft is advised. Both methods of treatment act by opening up vascular channels in the sclerosed bone ; the graft secures complete fixation and hastens bony union.

XII

INJURIES OF THE HAND AND FINGERS

FRACTURES OF THE FIRST METACARPAL

BENNETT'S fracture.—This is an oblique fracture of the base of the 1st metacarpal, and involves the articular surface of the bone at the carpo-metacarpal joint. The proximal fragment, consisting of the medial part of the base of the metacarpal, remains in its normal position, but the distal fragment, or shaft of the bone, is displaced proximally, backwards and laterally in the region of the "anatomical snuff-box" (Fig. 135). Owing to the fact that the most important movements of adduction and opposition of the thumb occur at this joint, accurate restoration of the fragments is of especial importance. In untreated cases, severe arthritic changes may occur, and considerable disability will then result.

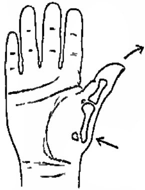


FIGURE 135

Displacement of the fragments in a Bennett's fracture. The arrows indicate the manipulation required for reduction.

(*After Böhler*)

Reduction.—Traction is applied to the thumb in the position of abduction and slight opposition, *i.e.* the thumb is held as for gripping a tumbler. At the same time, the shaft of the metacarpal is pressed forwards and medially into position (Fig. 136). Local anaesthesia is most effective: a few c.c. of 2 per cent. novocaine are injected around the fracture.

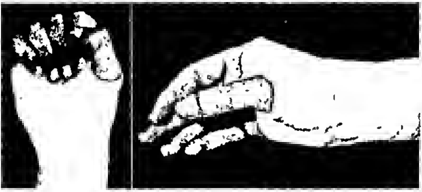
FIGURE 136

Reduction of a Bennett's fracture.

Immobilization.—A plaster cast is applied to the wrist and hand. It extends as far as the metacarpo-phalangeal joint of the thumb, and is carefully moulded round the metacarpal bone, while traction is maintained in the position described. During drying of the plaster, the base of the metacarpal is pressed well medially into the joint. The cast must not

extend beyond the palmar creases, in order that the fingers may be freely movable, and full flexion of the metacarpo-phalangeal joint of the thumb should be allowed (Fig. 138).

Continuous traction may be employed as routine, or it may be reserved for cases where the displacement tends to recur after the application of plaster. It is best carried out by transfixion of the pulp with a silkworm gut suture, which is held in a small stirrup (Fig. 140). A loop of thick wire, bent to resemble the end of a Thomas's splint, is incorporated in the plaster cast, and continuous



FIGURES 137 AND 138

Plaster cast for Bennett's fracture. Traction is maintained during its application. (The patient can assist in this, if the manipulation is carried out under local anaesthesia.) *The plaster is carefully moulded round the whole metacarpal bone,* the base of which is pressed well into the joint. The fingers are left with a full range of movement.

traction is carried out by means of stretched rubber tubing (Fig. 139). Traction by this method is quite painless, and gives rise to no ill after-effects. Alternatively, skin traction may be employed; adhesive strapping tends to slip, and methods depending on the use of Sinclair's glue or collodion are more satisfactory.

The fracture should be re-X-rayed after the plaster has dried. If there is the slightest tendency to re-displacement, continuous traction should *at once* be applied. The examination should again be repeated in two or three days' time, as the necessity for traction may then be apparent, or the traction already applied may require to be increased.

The plaster cast is retained for five weeks, but traction may be discontinued two weeks earlier. Active movements of the other fingers must be carried out during treatment.

Other fractures of 1st metacarpal. *Fracture of the base, not involving the joint.*—The first metacarpal is frequently fractured at the junction

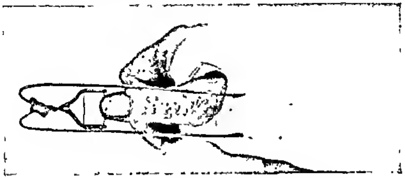


FIGURE 139

Continuous traction applied to thumb. The pulp of the thumb is transfixed (Fig. 140), and traction is carried out by means of stretched rubber tubing attached to a wire loop incorporated in the plaster.

of the base and the shaft. The fracture is usually transverse, and, unlike Bennett's fracture, it does not involve the carpo-metacarpal joint; it is often impacted with angulation pointing laterally and

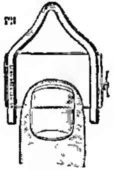


FIGURE 140

Stirrup for finger traction. The pulp of the finger is transfixed by a silkworm gut suture which is passed through the four holes in the stirrup.
(*Made for the author by Down Bros*)

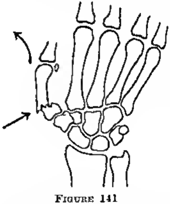


FIGURE 141

Fracture of the base of the 1st metacarpal, with typical deformity. Arrows indicate method of reduction. Strong pressure may be required to correct the angulation.

slightly backwards (Fig. 141). Reduction is effected by strong pressure at the site of angulation, while traction is applied to the thumb. Sometimes the impaction is so firm that it cannot be undone in this way. In such cases one or two sharp taps with a hammer over

the site of angulation will be found to be most effective (Fig. 142). A carefully moulded plaster cast is applied, as for Bennett's fracture, and is worn for three to four weeks. Continuous traction is not required.

Fractures of the shaft of the 1st metacarpal are uncommon. They

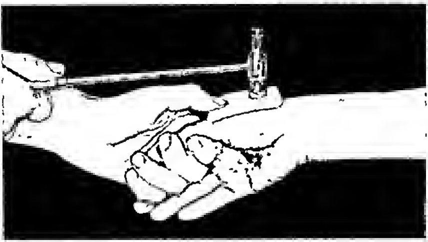


FIGURE 142

Impacted fracture of the base of the 1st metacarpal. The impaction is undone by one or two sharp taps with a hammer over the site of angulation.

are treated on the same lines as for Bennett's fracture. Continuous traction may be necessary to prevent re-displacement.

FRACTURES OF THE 2nd TO 5th METACARPALS

Fractures of the shaft.—These may be either transverse or oblique. The distal fragment is usually displaced by the action of the lumbrical and interosseous muscles, so that an angle pointing towards the dorsum is formed (Fig. 143). In oblique fractures, a varying degree of over-riding is present, and results in a corresponding loss in prominence of the affected knuckles.

The old method of treatment by means of a " closed-fist bandage " has nothing to commend it, as the existing angulation is likely to be increased, and no attempt is made to correct any shortening which may be present. Furthermore, all the fingers are needlessly immobilized.

In the absence of shortening, a plaster cast should be applied, extending to the knuckles. It is moulded against the fractured metacarpal, so that angulation is corrected (Figs. 143 and 144). A band of plaster should be carried round the palm to complete the immobilization, but it should allow full flexion of the fingers.

If over-riding is present, continuous traction should be employed. This can be carried out towards a loop of thick wire incorporated

in the plaster cast. Skin traction is usually effective (Fig. 145), but the method of transfixion of the pulp may be preferred (Fig. 140). The affected fingers should be in a slightly flexed position; this enables the other fingers to be exercised almost to their fullest extent.

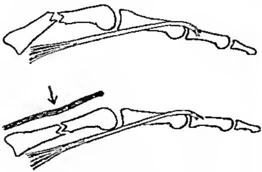


FIGURE 143

Typical displacement produced in fracture of the shaft of a metacarpal. Reduction is obtained by a plaster cast moulded closely to the dorsum of the hand (Fig. 144).

FIGURE 144

Traction of the fingers in full flexion is advised by Bohler, but in this position, unless the plaster is very carefully moulded, the angulation of the fractured metacarpals is liable to be increased.

Immobilization of the fingers in full extension is never permissible, because the capsule and lateral ligaments of the metacarpo-phalangeal

FIGURE 145

Continuous traction in the treatment of fractured metacarpals. It is obtained by a finger cot made of "*Elastoplast*," or by tapes affixed with Sinclair's glue. A loop of thick wire is incorporated in the plaster, and to this the fingers are pulled by means of stretched rubber tubing. They are in a slightly flexed position.

joints, which are normally lax in this position, will become contracted, and troublesome stiffness of the fingers in extension is likely to result. In addition, full flexion of the uninjured fingers will be impossible.

The plaster is retained for 3 to 4 weeks, but traction may be discontinued as soon as callus has formed. *Active* movements of

all the fingers are encouraged throughout the treatment, and are the best safeguard against subsequent stiffness.

Fractures of the neck of a metacarpal.—The head of the metacarpal is usually tilted towards the palm (Fig. 146), so that angulation

FIGURE 146

Fracture of the neck of a metacarpal, with characteristic deformity. The method of reduction is indicated.

pointing backwards is produced. Some degree of impaction is often present. The 5th metacarpal is most commonly affected.

Reduction.—The deformity cannot be reduced by hyper-extension of the finger at the metacarpo-phalangeal joint. The finger must be *flexed* to a right angle, and then pushed strongly backwards, while counter-pressure is exerted against the shaft of the metacarpal (Fig. 146). Local anaesthesia is excellent for this manipulation: a few c.c. of 2 per cent. novocaine are injected around the fracture.

Immobilization.—The most satisfactory way of maintaining correct alignment is to apply a plaster cast which includes the affected finger, and holds it flexed into the palm (Fig. 147). While the cast is drying, the finger is pressed backwards, so that the corrected position is maintained. Flexion of the adjacent finger is only slightly limited, and movement of the other fingers is quite unrestricted. Three weeks' immobilization is advised.

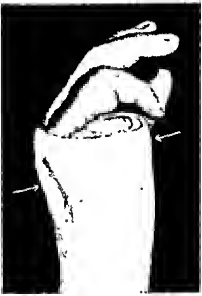


FIGURE 147

Plaster cast for fracture of the neck of the 5th metacarpal. It includes the finger, and holds it flexed into the palm. To maintain the corrected position (Fig. 146), the cast, while still moist, is moulded by pressure in the directions indicated. The 1st inter-phalangeal joint is protected with felt.

DISLOCATION OF THE THUMB

Dislocation of the thumb occurs most commonly at the metacarpo-phalangeal joint. As a rule it is caused by forcible dorsi-flexion, the

base of the phalanx being displaced on to the dorsum of the head of the metacarpal. Its importance lies in the fact that much difficulty is often experienced in effecting reduction. The phalanx

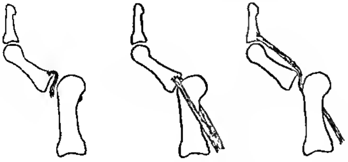


FIGURE 148

Alternative causes for the difficulty encountered in the reduction of a dislocation of the metacarpo phalangeal joint of the thumb.

A.—Torn palmar ligament interposed between joint surfaces.
B.—" Button-holing " of the two slips of the short flexor tendon around the neck of the metacarpal
C.—Long flexor tendon interposed between joint surfaces.

carries with it the palmar ligament of the joint together with the sesamoid bones, and these, by becoming interposed between the displaced articular surfaces, may form an obstacle to reduction.

FIGURE 149

The reduction of a metacarpo-phalangeal dislocation of the thumb. The first phalanx is pressed forwards on the metacarpal, while at the same time it is rotated medially.

Alternatively, the head of the metacarpal may have passed forwards through a " button-hole " formed by the rent in the capsule, or by the two halves of the short extensor tendon. In addition, the long

flexor tendon may pass *behind* the head of the metacarpal, and lie between the joint surfaces (Fig. 148).

Reduction.—The phalanx is first hyper-extended in order to extract the palmar ligament from between the joint surfaces, if it should occupy that position. An attempt is then made to coax the phalanx forward on to its normal position on the head of the metacarpal, while this bone is pressed in the opposite direction. At the same time the thumb is rotated medially to disengage the tendon of the long flexor from behind the metacarpal head. Traction in the axis of the thumb is rarely successful and should probably be avoided; on the theory of the "button-holing" of the head of the metacarpal, it will tend to render the margins of the opening more tight, and will thereby increase the difficulty of reduction.

If reduction cannot be effected by manipulation, open operation is undertaken. The joint is opened by a lateral incision, and the obstacle to reduction is dealt with under direct vision.

A light plaster cast may be applied after reduction, but re-dislocation is uncommon if dorsi-flexion is avoided. Adhesive strapping usually gives adequate support, and allows movement to be carried out.

FRACTURES OF THE PHALANGES

Fracture of the proximal phalanx.—As in fractures of the metacarpals, displacement of the fragments is caused by the action of

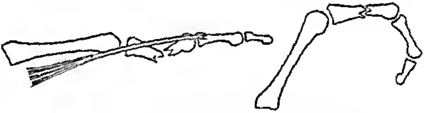


FIGURE 150

Drawing to show the displacement produced in a fracture of the proximal phalanx, and how it can be corrected by flexing the finger.

(After Böhler.

the lumbrical and interosseous muscles, but here the angulation is in the opposite direction, *i.e.* the angle points towards the palmar surface (Fig. 150). *Fixation on a straight splint is never permissible,* for it will maintain or aggravate this deformity, and permanent limitation of flexion will result.

Reduction is effected by applying traction with the finger in a position of flexion at both metacarpo-phalangeal and inter-phalangeal joints.

Immobilization.—As long as this is carried out in flexion, the method used is immaterial. A strip of aluminium $\frac{3}{4}$-inch wide makes a very effective splint, if it is bent accurately to conform with the

three joints of the finger; it may be applied to either the palmar or the dorsal surface (Fig. 151).

An alternative and very simple way of immobilizing a finger in

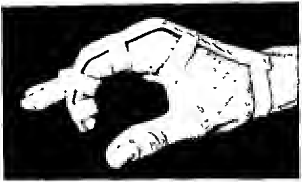


FIGURE 151

Aluminium splint applied for fracture of the proximal phalanx.

the flexed position consists in stitching the finger tip to the palm of the hand (Fig. 152). *With the aid of a local anaesthetic, a silkworm*

FIGURE 152

A useful method of correcting angulation in a fracture of proximal phalanx of the 5th finger. The finger is immobilized in the flexed position, by stitching its tip to the skin of the palm of the hand at a point near the base of the thenar eminence.

FIGURE 153

Continuous traction applied to finger by transfixion of the pulp with a Brock's pin. This is tied to a loop of wire which is shaped like the end of a Thomas's splint and is incorporated in the plaster. The wire is bent to correspond with the joints of the finger.

gut suture is passed through the pulp of the finger, and also through a small segment of skin on the palm of the hand, at the point where the finger tip touches when flexed *individually*. This site is carefully chosen, it being remembered that the plane of flexion of a finger is

not parallel with the axis of its metacarpal (except in the case of the middle finger). All the fingers converge, when flexed individually, towards the base of the thenar eminence. The stitch is tightened

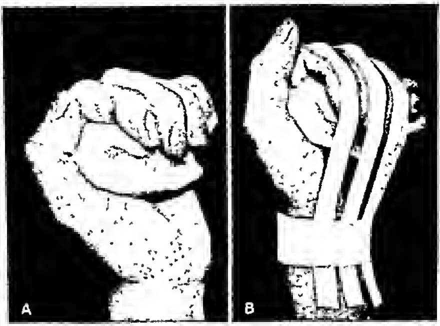


FIGURE 154

Treatment of fractured phalanges.

A.—Plaster bandage moulded to the palmar aspect of the hand and fingers.
B.—Fingers strapped in position. Considerable traction may be applied.

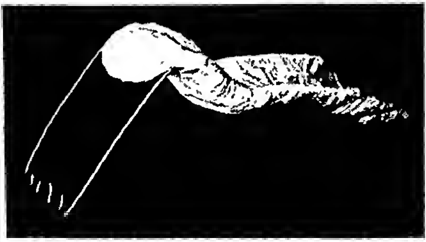


FIGURE 155

Plaster slab with wire extension for applying continuous traction to fingers. The plaster is moulded to the palmar aspect of the hand and fingers, and is allowed to dry before the traction is applied. (Fig. 156.)

until the finger tip is almost touching the palm. This method of treatment provides satisfactory immobilization, and is particularly

useful in the case of the 5th finger, to which it is difficult to apply an effective splint. Fixation by this means is painless, and there is no tendency to sepsis.

Where two or more fingers are fractured, the method of treatment

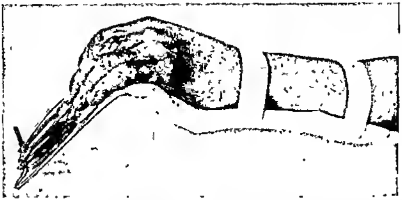


FIGURE 156

A case of compound fracture of the proximal phalanges of three fingers—treated by continuous traction. The pulp of each finger is transfixed in the manner shown in Figs. 139 and 140, and the traction is carried out by means of stretched rubber tubing.

shown in Fig. 154 has proved very efficacious. The fractured fingers are strapped over a cylinder made from a 4-inch plaster of Paris bandage. Considerable traction may be applied in this manner.

FIGURE 157

Continuous traction applied to a finger for fracture involving the terminal joint. The finger is tied to the end of the splint by a stitch transfixing the pulp.

Continuous traction.—If the fracture involves the articular surface of the phalanx, or if reduction is found to be unstable, continuous traction should be applied. This is indicated also in compound fractures, and in cases where excessive bruising of the soft tissues has occurred, as in such circumstances it is difficult to apply a splint effectively. Methods of applying continuous traction for fractures of the proximal phalanges are illustrated in Figs. 153 and 156. For the reasons already given, *it is essential that the fingers should be flexed.* The old-fashioned "banjo" splint must be utterly condemned.

Immobilization is maintained for about 3 weeks. Thereafter, active movements are encouraged.

Fractures of the 2nd and 3rd phalanges.—*In fractures of the* middle phalanx angulation is rarely so marked as in the case of the

proximal phalanx, but treatment is carried out on similar lines. Crush fractures of the terminal phalanx without displacement are adequately protected by adhesive strapping. A method of applying continuous traction in fractures of the distal two phalanges is shown in Fig. 157.

Fractures of the phalanges of the thumb.—Fractures of the distal phalanx are commonly due to crushing injuries. Although considerable comminution may be present, displacement is usually slight. In such cases, adequate splintage can be provided by adhesive strapping.

FIGURE 158

Plaster cast for fracture of proximal phalanx of thumb. The thumb is held in the position required for gripping a tumbler.

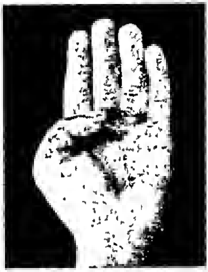


FIGURE 159

Alternative method of correcting angulation. The tip of the thumb is stitched to the skin overlying the 4th metacarpo-phalangeal joint.

Fractures of the proximal phalanx frequently show angulation of the fragments. As in the case of similar fractures of the fingers, the angle points towards the flexor surface; this is due to the pull of the short flexor and adductor muscles acting on the proximal fragment. The angulation may be corrected by immobilizing the thumb in flexion and slight opposition, *i.e.* the thumb is fixed in the position for holding a tumbler (Fig. 158). If the angulation is more marked, it may not be completely corrected in this position. More acute flexion is required: a useful method of obtaining this is to stitch the pulp of the thumb to the skin overlying the 4th metacarpo-phalangeal joint (Fig. 159). After a fortnight the stitch is removed, and a plaster cast is applied with the thumb in the position first described.

If the fracture involves either of the joints of the thumb, or if there is persistent over-riding of the fragments, continuous traction should be applied. This is carried out as in the treatment of Bennett's fracture, but both joints of the thumb should be flexed.

A wire extension is incorporated in the type of plaster cast shown in Fig. 158, and pulp traction is applied.

"MALLET" FINGER

This condition is due to a partial or complete tear of the extensor tendon, at its insertion into the base of the terminal phalanx. Sometimes a chip of bone bearing the insertion may be avulsed. As the result of the injury, the terminal joint is fully flexed, and cannot be actively extended.

Treatment.—The part of the tendon which is torn is formed by the two lateral slips of the extensor expansion, which fuse together before being inserted into the base of the terminal phalanx. This part of the tendon must be *fully relaxed for healing to occur.* If the finger is immobilized with both inter-phalangeal joints in extension, the torn tendon is still subjected to strain produced by voluntary *extension at the metacarpo-phalangeal joint (Fig. 160). This strain*

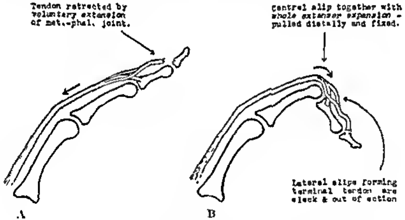


FIGURE 160

Rationale of treatment of "mallet" finger.

A.—Finger immobilized in full extension at *both* inter-phalangeal joints. The terminal part of the tendon is still subject to strain.

B.—Finger immobilized with the proximal inter-phalangeal joint in right-angled flexion. Terminal part of tendon is completely relaxed.

can be prevented if the proximal inter-phalangeal joint is flexed. In this position, the central slip of the tendon, together with the whole extensor expansion, is pulled distally and fixed; *the terminal part of the tendon is slack and out of action, and is unaffected by movement* at the metacarpo-phalangeal joint. It is advised therefore that the finger should be immobilized, not only in hyper-extension at the terminal joint, but also *in right-angled flexion at the proximal inter-phalangeal joint.*

Splints are unsatisfactory, and the best method of treatment

is that described by Smillie. A strip of 3-inch plaster bandage about 2 feet long is rolled into a tube round the finger; it may be cut obliquely at its proximal end, so that it fits round the web, while still covering the greater part of the dorsum of the finger. The finger is dipped in warm water, and the wet plaster cylinder is rapidly moulded around it. The patient then holds the finger in the position described until setting has occurred. To avoid pressure sores, it is important that the patient, and not the surgeon, should hold the finger in position; he is accordingly made to practise this before the plaster is applied.

FIGURE 161

Tube of dry plaster bandage enclosing finger. It may be cut obliquely at the web.

The cast is worn for 5 to 6 weeks. It does not interfere with the active use of the hand, and no stiffness should result.

Open operation is indicated in unsuccessful cases. The torn end of the tendon may have become turned in between the joint surfaces,

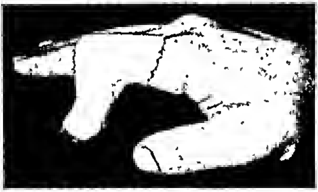


FIGURE 162

Position in which finger is held until the plaster has set. The tip is pressed against the table or against the thumb.

when it should be replaced, and, if possible, sutured in position. The finger is again immobilized in plaster.

PART IV

PELVIC GIRDLE AND LOWER EXTREMITY

XIII

FRACTURES OF THE PELVIS

TREATMENT OF THE BONY INJURY

THE different varieties of fracture of the pelvis require special consideration in regard to the treatment of the bony injury. Associated injuries to the pelvic viscera are not considered here.

Fractures of the false pelvis (*i.e.* above the pelvic brim).—These usually involve only the upper and outer part of the ilium, and are

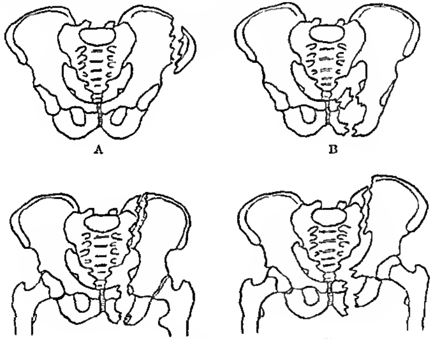


FIGURE 163

Diagram to show the different types of fracture of the pelvis.

A.—Fracture of upper and outer part of the ilium.
B.—Anterior fracture, involving rami of pubis. Note how a fragment may be displaced inwards.
C.—*Double fracture of the pelvic girdle, with* lateral rotation of the whole fractured segment.
D.—Double fracture with upward displacement of fractured segment and lower limb as a whole.

of minor importance, as they give rise to no internal injury, and as a rule little or no displacement occurs (Fig. 163 A).

Treatment.—A firm binder or adhesive strapping applied round

the pelvis gives a comfortable sense of support to the patient, and, in the absence of displacement, is all that is required. Where the anterior part of the iliac crest bearing the anterior superior spine is

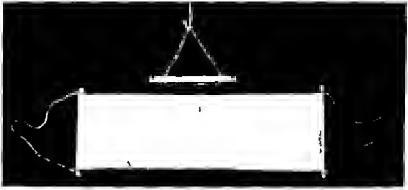


FIGURE 164

Hammock sling with spreader used in the treatment of fractures of the pelvis. (*After Böhler*)

involved, the hip joint should be placed in flexion, in order to relax the muscles arising from that part. In certain cases, it may be advisable to perform an open operation, and to peg the fragment back into position.

Fractures of the anterior part.—These commonly involve the rami of the pubis. If both rami on one side are fractured, some separation of the fragments may occur, due to slight rotation of the pelvic

FIGURE 165

Fractured pelvis treated by suspensory sling.

segment at the sacro-iliac joint. If separation is marked, a dislocation or fracture-dislocation of this joint should be suspected. A double fracture of the superior pubic ramis is not uncommon, and in

such cases a fragment may be displaced towards the pelvic cavity (Fig. 163 B).

Treatment.—Fractures without displacement require no treatment beyond recumbency for a few weeks. A binder or adhesive strapping should be applied to give support to the pelvis. Separation of the fragments cannot however be corrected by this means; a binder rapidly works slack, and adhesive strapping, if applied sufficiently tightly to be effective, is very liable to cause excoriation of the skin.

In such cases, a suspensory sling (Figs. 164 to 166) may be used to produce continuous side-to-side compression of the pelvic girdle. If the separation is not at once corrected, the cords of the sling may be crossed (Fig. 166). Very considerable pressure is then exerted, and the patient may soon complain of discomfort, but the separation is usually corrected within 24 to 48 hours, and the pressure can then be reduced by lengthening the cords between the sling and the spreader, or by returning them to the uncrossed position. For the purpose of varying the amount of compression, a spreader with several notches may be used. In addition to the lateral compression which it exerts, the sling enables the patient to move about in bed without discomfort, and he can raise his pelvis much more easily for nursing purposes.

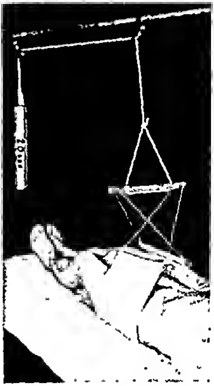


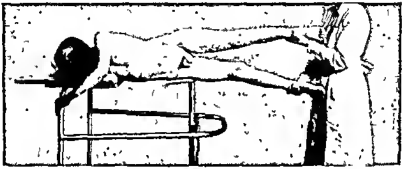
FIGURE 166

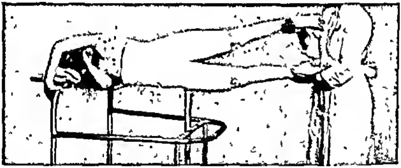
The sling arranged so as to provide side-to-side compression of the pelvic girdle.

Displacement of a fragment towards the pelvic cavity may prove very difficult to correct, but healing usually occurs without subsequent disability. In the female, reduction of the diameters of the pelvic brim or outlet may interfere with childbirth. An attempt may therefore be made to press the fragments into position by a finger in the vagina.

Dislocation of the pelvis.—This commonly occurs when a fracture or dislocation involves both anterior and posterior segments of the pelvic girdle. Subluxation of the sacro-iliac joint may be accompanied by disruption of the symphysis pubis, with wide separation of the pubic bones. In "*fore and aft*" fractures there is usually an anterior fracture involving the pubic rami, combined with a fracture of the posterior part of the girdle. This may pass through the ala of the

sacrum or back of the ilium, and may be in the nature of a fracture-dislocation of the sacro-iliac joint. The *anterior and posterior lesions* may be on the same or on opposite sides of the pelvis. Two different types of displacement may occur. The side of the pelvis which has lost its attachment to the sacrum may be rolled laterally, producing a wide separation between the fragments anteriorly. Alternatively, the separated half of the girdle, together with the lower limb on that side, may be displaced upwards (Fig. 163, C and D).





FIGURES 167 AND 168

Reduction of a dislocation or fracture-dislocation of the pelvis by the method of "lateral recumbency" (Watson Jones). The dislocated ilium is pressed forwards and downwards, and a double plaster spica is applied.

Treatment.—For the correction of rotational deformity, the method of compression by a suspensory sling is usually effective. The lower limb on the affected side should be controlled by a splint.

Watson Jones advises the method of "lateral recumbency" in the treatment of such displacement. The patient is placed on an orthopaedic table with the ilium and trochanter of the affected side lying on the pelvic rest, from which the upright has been removed. The two lower limbs are held one above the other by an assistant (Fig. 167). In this position reduction may occur spontaneously, and without anaesthesia. Gross displacement may be corrected by downward pressure over the crest of the dislocated ilium. If neces-

sary, the patient may be laid on the injured side, so that the lateral compression is increased by the addition of body weight. Accuracy of reduction should be confirmed by radiographs taken with the patient in the lateral position. The iliac crests are protected with

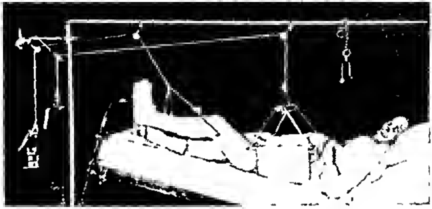


FIGURE 169

A case of fracture dislocation of the pelvis with upward displacement. Treated by skeletal traction (56 lbs.) applied to supra-condylar region of femur, and by compression sling. The plaster cast serves only to support the lower limb

adhesive felt, and a double plaster spica is applied (Fig. 168). This must be carefully moulded to the pelvis and lumbar region. The pelvic rest is then cut out, padding is inserted, and the gap in the

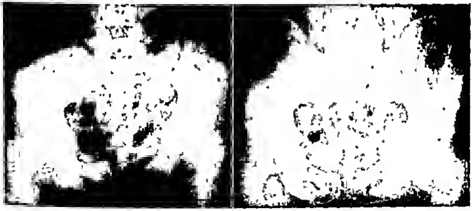


FIGURE 170

Radiographs of patient shown in Fig. 169—before and after reduction by the method described. Note that a fracture of the ilium, involving the sacro-iliac joint, is combined with a dislocation of the symphysis pubis. (*Radiographs with portable apparatus.*)

plaster repaired. Immobilization is continued for three months, during which time the patient is encouraged to lie on his side as much as possible. The plaster may require renewal in four or five weeks, and a new spica is applied, again in the position of lateral recumbency.

Where upward displacement exists, continuous traction must be applied to the lower limb on the affected side, by one of the methods described for the treatment of fractured femur. The displacement may not be reduced until a very heavy weight has been applied—possibly 60 lbs. or more. The foot of the bed is raised to a corresponding height to provide the necessary counter traction. Skeletal traction (Fig. 169) is of course essential, and it should be applied directly to the femur.

Fractures of the acetabulum.—Either the upper rim or the floor of the acetabulum may be affected. Fractures of the upper rim are combined with upward dislocation of the hip joint. Fractures of the floor may be in the nature of a simple fissure without displacement, or there may be extensive destruction of the bone, with displacement of the head of the femur towards the pelvic cavity ("*central dislocation*").

Treatment.—In all cases continuous traction must be applied to the limb. In fissured fractures of the floor of the acetabulum without displacement, a relatively small weight (10 lbs.) may be used, as it is only necessary to prevent pressure of the head of the femur against the fractured surface. If central dislocation is present, very strong traction is required to pull the head of the bone out of the pelvis, and this is carried out by skeletal traction applied directly to the femur. Traction on the limb in a position of moderate abduction may be efficacious, but if not, it is recommended that direct lateral traction should be applied by means of a pin or wire passed through the trochanter. After reduction is effected, the traction is reduced. In some cases *screw traction* may be required: this is carried out on an orthopaedic table (Fig. 198). After reduction has been effected, continuous traction must be maintained.

After-treatment.—*In fractures of the false pelvis and in uncomplicated anterior fractures,* the patient is kept in bed for four to six weeks, after which time weight-bearing is gradually commenced.

In dislocations and fracture-dislocations, immobilization is continued for three months, and radiographs are taken at regular intervals to ensure that the position is maintained. In cases where upward displacement has occurred, a further of 6 to 8 weeks interval should elapse before weight-bearing is permitted.

Acetabular fractures.—If there is no displacement, traction is discontinued in about eight weeks' time, after which weight-bearing with the protection of a walking caliper splint may be allowed.

Where *central dislocation* is present traction should be con[illegible]d *for at least three months*, and a further period of three months is [illegible] to elapse before full weight-bearing is und[illegible] Arthritic [illegible] are very liable to occur; the prognosis as [illegible] poor, and arthrodesis may eventually be r[illegible]

XIV

THE HIP JOINT

CONGENITAL DISLOCATION OF THE HIP

THE results of non-operative treatment of congenital dislocation of the hip depend largely upon the age at which treatment is instituted. The longer the deformity is allowed to exist, the greater will be the difficulty encountered in the reduction, and the less likelihood is there that a functionally satisfactory joint will ultimately be obtained. While the dislocation remains, not only is normal development prevented, but increasing atrophy of the upper part of the acetabulum may occur.

In infants under the age of 18 months, no special manipulation is required for the reduction of the dislocation. The head of the femur can be brought opposite the acetabulum and upward displacement prevented, by maintaining the limbs in a widely abducted position. For this, Putti's mattress may be used. This is a small triangular mattress of firm consistence, which is covered with mackintosh, and to which the child's legs are strapped (Figs. 171 and 172). It is worn continuously and provides efficient immobilization, as the child can be carried about with the mattress in position. It is removed once or twice daily for cleaning purposes. Splints which fulfil the same purpose may be substituted. This treatment may be employed for 6 to 12 months depending upon circumstances, and in young infants is always preferable to a plaster cast. In favourable cases, radiological examination will show steadily increasing development of the acetabulum.

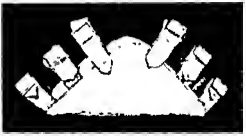


FIGURE 171
Putti's mattress.

Manipulative reduction.—In this country, where congenital dislocation is relatively uncommon, the diagnosis is usually made only after weight-bearing has commenced. In such cases, the dislocation is more established, and is unlikely to be reduced by the simple method of abducting the legs. Several methods of manipulative reduction are described, the majority being based on that originally described by Lorenz, except that the preliminary forcible stretching of the muscles is now omitted. If much shortening is present, this is corrected by continuous traction before reduction is attempted.

The following method of reduction is given by Jones and Lovett. The child is placed on its back with the affected side nearer the edge of the table, and the pelvis and opposite thigh are fixed by an assistant. The hip and knee joints on the affected side are flexed to a right angle, and the limb is then rotated medially; while the flexion and rotation are maintained, the thigh is now abducted, so that the lower leg points downwards towards the floor (Fig. 173 C). At the same time, pressure is applied behind the trochanter, in an attempt to lever the head forwards into the acetabulum. Reduction may then take place with an audible snap, as the head slips over the acetabular rim. The thigh is now gently rotated laterally, while the abducted position is maintained, so that both thigh and lower leg lie in the plane of the table (Fig. 173 D).

FIGURE 172

Treatment of congenital dislocation of the hip in a young infant, by means of Putti's mattress. Note the associated club foot deformity.

Two or three attempts may be necessary before reduction is effected. If these are unsuccessful, open operation should be undertaken.

Immobilization.—After reduction has been carried out, it is essential that the joint should be immobilized in a position which will prevent a recurrence of the displacement. The optimum position is that described for the last stage of the manipulation, *i.e.* the knee is flexed, and the thigh is widely abducted and rotated laterally. The rotation should be extreme—so that the medial surface of the knee lies in or behind the plane of the two anterior superior iliac spines, and the patella is pointing laterally. In order to secure adequate immobilization of the affected joint, both limbs must be fixed. Even in cases of unilateral dislocation, it is the usual practice to put up both limbs in the same degree of abduction and lateral rotation. The term "*frog position*" is particularly descriptive.

A well-padded plaster cast is employed (Fig. 174). It extends above to the nipple line, and below it includes the leg and foot on each side. It is carefully moulded behind the trochanter in order to keep the head of the bone pressed forward against the anterior part of the capsule. The cast is well cut away from the region of the perineum to prevent soiling, and a window may be cut over the abdomen. The child should be laid on a frame, which keeps it elevated from the bed and facilitates nursing.

FIGURE 173

Manipulative reduction of congenital dislocation of the hip.

A.—The hip and knee joints are flexed to a right angle.

B.—The limb is rotated so that lower leg points laterally.

C.—Wide abduction. At this stage strong pressure is applied behind the trochanter in order to lever the head of the femur forwards into the acetabulum.

D.—Finally the limb is laterally rotated in order to bring the thigh and lower leg into the plane of the table.

After-treatment.—It is advised that the first plaster cast in the full "frog" position should be retained for at least three months. Two or three further casts will be required for similar periods, and in *these the limb is gradually brought down to a more normal position.* Radiographic examination is carried out at regular intervals during treatment, to ensure that reduction is being maintained, and to envisage the development of the upper rim of the acetabulum. Such examination will determine the position to be maintained, and the

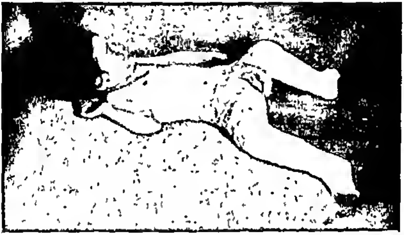


FIGURE 174

Plaster cast in the "frog" position—advised for immobilization of the hip joint in cases of congenital dislocation.

(*Mr. R. I. Stirling's case.*)

duration of the immobilization. Later treatment consists of massage, graduated exercises, and re-education in walking.

In the majority of cases treated by conservative measures, the acetabulum will develop sufficiently for a functionally useful joint to be obtained; in the most favourable cases a joint almost indistinguishable from normal may result. In a proportion, however, and especially in older children, such development is not achieved, so that continued instability of the joint remains, and re-dislocation inevitably occurs. A successful result is then unlikely to be obtained by further conservative treatment, and an operation for the reconstruction of the roof of the acetabulum should be undertaken.

TRAUMATIC DISLOCATION OF THE HIP

Dislocation of the hip occurs most frequently in strong muscular adults as the result of severe violence. The mechanism of the injury determines the type of dislocation produced.

Posterior dislocation is much the commoner type. It is caused

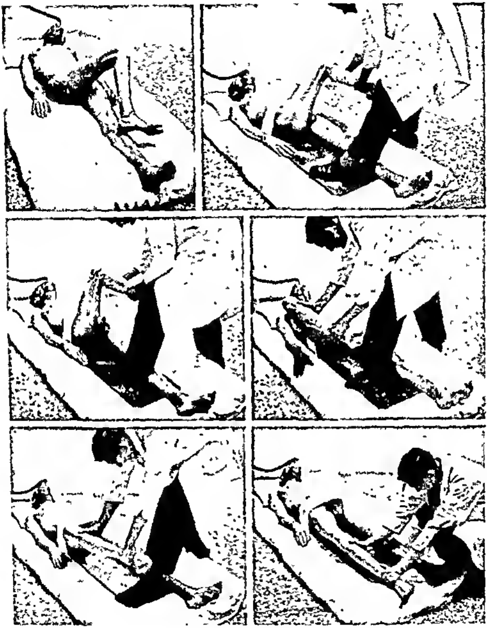


FIGURE 175

Posterior dislocation of right hip.

Photographs showing the characteristic deformity, and the different stages in the reduction.

by injuries which tend to force the flexed femur backwards on the pelvis. The head tears through the lower and back part of the capsule, and comes to rest on the dorsum ilii, above and behind the acetabulum.

The appearances are seen in the first photograph (Fig. 175). As the articular surface of the femoral head is directed backwards, the limb is in a position of marked medial rotation; it is also flexed and adducted so that the knee lies above the opposite thigh: definite shortening is present. It may be impossible either actively or passively to straighten the limb.

In some cases the head of the femur passes posteriorly *below* the *tendon of obturator internus.* Its upward movement is then checked by the tendon, and the displacement, although of the same type, is less marked.

Reduction of the dislocation.—Full anaesthesia should be induced, as complete muscular relaxation is required. The patient is laid on a mattress on the floor, and his pelvis is firmly bandaged to a large board. By standing on the board, the surgeon has control of the pelvis during the manipulation of the limb. (Böhler.)

The thigh is first fully flexed in order to relax the ilio-femoral ligament. An attempt is then made to cause the head of the femur to retrace its steps forward into the acetabulum. For this, strong traction is required with the thigh flexed, *i.e.* an attempt is made to lift the patient by the leg, while the pelvis is held down to the board. During the application of traction, the limb is steadily abducted, rotated laterally, and finally extended. In the course of this manipulation the head of the femur should enter the acetabulum with an appreciable click. Several attempts are often required before reduction is effected.

Anterior dislocation is relatively uncommon. It is most liable to be caused by excessive abduction of the thigh. The joint capsule is torn at its inferior or antero-inferior part, and the femoral head, passing forward and then medially, comes finally to rest against the obturator foramen. The appearances are seen in the first photograph (Fig. 176). As the head o fthe femur is directed mainly forwards, the limb is fixed in a position of lateral rotation and abduction, and lengthening is present.

Reduction of the dislocation is carried out in a manner which corresponds to that described for the posterior dislocation. The thigh is first fully flexed, and is then circumducted medially. A varying amount of traction may be required. During the latter part of the rotation, the flexed knee should be pressed downwards, to force the femoral head posteriorly into the acetabulum.

After-treatment.—In the absence of any fracture, immobilization of the hip joint after dislocation is usually considered to be unnecessary, but the knees are kept bandaged together for several

Figure 176

Anterior dislocation of right hip.

Photographs showing the characteristic deformity, and the different stages in the reduction.

days to restrict movements. Weight-bearing is permitted in three to four weeks' time. Re-dislocation is rare.

TUBERCULOSIS OF THE HIP

The local treatment of tuberculosis of the hip joint is concerned with the relief of pain, the correction of deformity, and the provision of complete rest to the joint.

Relief of pain.—The pain, which is acute in the early stages of the disease, is due to movement of the inflamed joint, and to muscular spasm. The spasm is induced by contact between the roughened articular surfaces, and is immediately abolished by the application of traction to the limb. If traction is combined with complete immobilization of the joint, the pain is rapidly alleviated.

Correction of deformity.—At the stage in which many cases come for treatment, adduction and flexion deformity is established, and its correction is an essential feature of the treatment. Such correction must be *gradual*, as any forcible measures tend to disseminate the disease, and to break down barriers of natural resistance. Forcible manipulation is not only harmful — it is unnecessary. If the deformity is due to muscular spasm or to soft adhesions, it can be overcome equally well, and with considerably less risk, by gradual methods: on the other hand, if it is due to bony deformity or to fixed muscular contracture, operation offers the only prospect of its correction.

Rest to the Joint.—After the deformity has been corrected, the joint must be immobilized until cure of the local condition has taken place. Such fixation of the joint must be carried out in the optimum position for future usefulness, should fibrous or bony ankylosis ensue. Even in the absence of shortening, the limb should be immobilized in at least some degree of abduction, as during the stage of healing there is an invariable tendency for muscular spasm to produce a recurrence of the adduction deformity.

Traction methods.—Traction serves not only to prevent pressure between the diseased articular surfaces and to alleviate muscular spasm; it can also provide for the gradual correction of deformity. It is best obtained by means of skin strapping applied to the limb in the manner described for fracture of the femur (p. 171). A weight depending upon the size of the child (and 1 lb. per year of its age has been suggested) is attached to the strapping, and the foot of the bed is raised to provide counter-traction. The traction is at first applied in the axis of the limb in the existing position of deformity, and abduction is gradually attained by altering the direction of the pull. Even in the absence of deformity, the limb should be placed in the abducted position to counteract the spasm of the adductor muscles which sooner or later will take effect. In order to maintain the

abduction as far as possible, it is of advantage to fix the healthy leg in a similar position, by means of a sling tied to the side of the bed (Fig. 177).

Traction combined with plaster fixation.—This is advisable in many cases, and particularly if there is a considerable degree of adduction

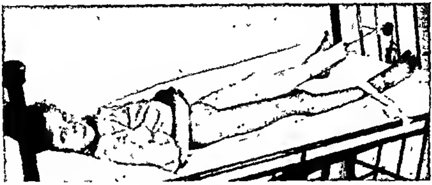


FIGURE 177
Traction applied by means of skin strapping, in a case of tuberculosis of the hip joint.

deformity to be overcome. If the unsupported leg is steadily pulled into the abducted position, a genu valgum deformity may result from stretching of the medial collateral ligament of the knee. This may be prevented by enclosing the limb in a light plaster cast extending up as far as the groin. The plaster is applied over the skin strapping

FIGURE 178
Method of correcting adduction deformity in tuberculosis of the hip joint. Traction is applied by skin strapping, and the angle of abduction is gradually increased. A light plaster cast applied over the strapping prevents the development of genu valgum. Care must be taken that no traction is transmitted directly to the plaster.

and should include the foot. The strapping emerges through two windows in the cast above the ankle (Fig. 178). Care should be taken that none of the traction is communicated directly to the plaster cast, or pressure sores over the dorsum of the foot will rapidly result.

In some cases, in order to secure complete rest to the joint, it is advisable to employ a plaster cast carried up on to the trunk, which fixes the limb in the desired position. Continuous traction may be carried out as before (Fig. 179).

Traction on special frames.—Many different types of frames or

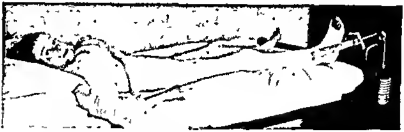
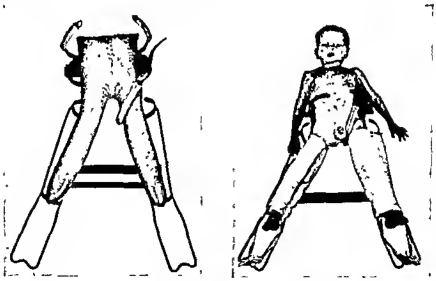


FIGURE 179

Traction applied to the limb while the abducted position is maintained by a hip plaster. Note how the strapping emerges through two slits in the cast.

splints have been used. *Jones's abduction frame* (Figs. 180 and 181) is efficient and easily handled. It is so designed that the affected joint can be retained at any angle of abduction which the surgeon



FIGURES 180 AND 181

Jones's abduction frame used in the treatment of tuberculosis of the hip joint.

(Courtesy of Messrs. E. Arnold & Co, London)

desires. Traction is carried out by means of strapping applied to the leg and thigh, and tied to extensions resembling the ends of Thomas's splints, attached to the frame. Counter traction is provided by a groin strap which exerts pressure on the ischial tuberosity of the

opposite side. Additional fixation of the pelvis is obtained by applying traction in a similar manner to the sound limb. The legs are bandaged firmly to the frame, and a large pad is placed behind each knee to prevent hyper-extension. As the muscular spasm is overcome, the traction works loose and requires to be tightened at intervals. The frame is so constructed that nursing details and the skin of the back can be attended to without in any way interfering with the efficacy of fixation.

Immobilization.—*If destruction of bone is slight or absent,* immobilization may be obtained simply by continued traction in the desired position, in the hope that, if pressure between the articular surfaces can be prevented, some mobility of the joint may be preserved. It is rare however for this hope to be justified.

Where definite destruction is present, bony ankylosis should be

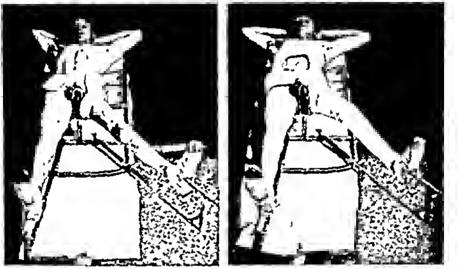


FIGURE 182

Application of plaster cast in the treatment of tuberculosis of the hip joint. The patient is placed on the Portable Traction Table (Plate XXXIV), which leaves the trunk and limbs entirely free. Felt pads are placed over the anterior superior spines, round the medial side of the thigh, and over the vertebral column and sacrum. Note the position of abduction at the hip joint, and slight flexion at the knee.

the object of treatment, for this offers the best prospect of lasting cure. Traction is therefore discontinued as soon as the desired position has been obtained, and a well-fitting plaster cast is applied, extending upwards to the costal margin, and enclosing the entire limb. The optimum position of abduction varies, within limits, in direct proportion to the amount of shortening present. In addition to the required amount of abduction, slight flexion at both hip and knee joints, together with slight lateral rotation of the limb, should be secured. The plaster cast may be mainly unpadded, in which case

felt pads should be placed over the vertebral column, over the anterior superior spines, and round the medial side of the thigh (Fig. 182). The cast is carefully moulded round the trochanters and iliac crests.

After-treatment.—The duration of immobilization will depend upon the general and local conditions, and upon radiological evidence of healing. One to two years may be taken as the average time during which immobilization must be maintained. The plaster cast is renewed as required.

Mercer suggests that, after the plaster has been removed, there should be a period of three months when the patient is allowed free movement in bed unhampered by any apparatus. Thereafter, gradual weight-bearing may be allowed, provided that there has been no recurrence of symptoms or deformity, and X-ray examination shows satisfactory re-calcification of the diseased bone. A walking caliper splint (Fig. 196) may be employed at the commencement of ambulant treatment.

A careful watch is kept, not only for a recurrence of adduction deformity, but also for any lessening of the abduction which may have been obtained by treatment.

Operative treatment.—This is designed to secure ankylosis of the joint, usually by an extra-articular fusion. It is indicated where a thorough trial of conservative treatment has failed to cure the disease, or has been followed by a recurrence. It has a special place in the treatment of adults.

XV

FRACTURES OF THE NECK OF THE FEMUR

SUB-CAPITAL FRACTURES—THE SMITH PETERSEN NAILING PROCEDURE

THE prognosis in cases of sub-capital fracture of the neck of the femur in old people has been improved enormously in recent years by Smith Petersen's invention of a metal pin with three radiating flanges. This pin or nail is driven along the axis of the neck of the femur into the head, and secures complete fixation of the fragments in apposition. The flanges of the nail are so thin that there is the minimum of destruction to the spongy bone, and the fragments are prevented from rotating on one another, as they are liable to do when a round peg or nail is used. The nail usually remains so firmly fixed that it can be removed only with difficulty.

In the early days of the operation, the nail was inserted under direct vision, but the necessary wide exposure constituted a severe operation, in which there was a grave danger, not only of shock, but also of interference with the blood supply of the joint structures.

A much less severe operation has been made possible by the introduction of cannulated nails, first by Sven Johannson, and later by Watson Jones. Such nails having a channel in their central axis can be threaded on a wire guide; this is inserted first into the bone, and its position confirmed by radiographs which are developed during the course of the operation. Several attempts may be necessary before the correct alignment of the guide is obtained, or two or three guides may be inserted at the one time and the best one selected. A nail of suitable length is then threaded on to it and is driven home into the bone. In this "blind" operation, no exposure of the hip joint is necessary; a small longitudinal incision over the junction of the greater trochanter and shaft is all that is required. The operation can usually be performed without difficulty under local anaesthesia.

FIGURE 183

Cannulated Smith Petersen nail (*Watson Jones*), showing also end view of head and point.

It is claimed that there are practically no contra-indications to the nailing operation, except possibly in the rare cases where there is such comminution of the fragments that the nail could not be expected to hold. Certainly extreme

old age and feebleness are not in themselves a bar to a successful operation. Where local anaesthesia is employed the operative shock is negligible, and the risk of post-operative complications is minimized. There is immediate relief from pain which is due to movement at the site of fracture and to associated muscular spasm. The patient is able from the first to sit up unaided and to change position in bed, so that the liability to chest complications and bed sores is greatly reduced.

The cannulated nail of Watson Jones and the associated instruments are illustrated in the Appendix (Plate XXIX), where a short description of the use of each is included.

It is essential that a portable X-ray apparatus should be available, and that the films should be developed during the course of the operation. It is very desirable, although not absolutely necessary, to employ an orthopaedic table, on which the affected limb can be fixed in a position of abduction and medial rotation.

The nailing operation may be carried out within a few hours of the patient's admission, or it may be delayed for several days. There is probably nothing to be gained by such delay, and where facilities are available arrangements should be made for operation as soon as possible.

Reduction of the fracture.—The great majority of sub-capital fractures are of the so-called "adduction" type, in which two deformities are commonly present—upward displacement and lateral rotation of the lower fragment. The correction of these deformities is not only an essential preliminary to the nailing operation, but it should be the first step taken to ensure the patient's comfort and to facilitate nursing.

If the nailing operation can be performed within 24 to 48 hours, it may be advisable to postpone the reduction until that time, when the one anaesthetic will suffice for both reduction and operation.

If the nailing operation is to be delayed, reduction should be carried out as soon as possible after the patient's admission. In a few cases it may be possible to correct the lateral rotation without anaesthesia simply by rolling the leg medially and supporting it between sandbags. It should be noted however that reduction has been successfully accomplished only if the limb can be made to lie in normal rotation *without* the sandbags; the function of these should simply be to prevent a *recurrence* of the lateral rotation after this has been corrected. Continuous traction must also be applied to the limb to reduce the shortening which is almost invariably present. This may be carried out by means of skin traction on the leg as it lies between sandbags. In general however the method of fixation of the limb between sandbags is to be condemned except as a very temporary measure, as whenever the patient attempts to change

position in bed, movement inevitably occurs at the fracture site, causing considerable pain and discomfort. It is much more satisfactory to secure the traction by one of the methods described for fractures of the shaft of the femur, where the leg is suspended clear of the bed and the rotation is more efficiently controlled. In addition the nursing is made very much easier. Traction in a Hodgen's splint or Russell traction is particularly suitable (pp. 182 to 187).

In the majority of cases an anaesthetic is required, as, owing to muscular spasm or to partial impaction of the fragments, the lateral rotation cannot otherwise be corrected. A satisfactory method of reduction is illustrated in Fig. 184. In this, traction is applied to the

FIGURE 184

Forcible reduction of a sub-capital fracture of the neck of the femur. Traction is applied to the femur in a position of flexion and medial rotation. The operator passes his arm under the flexed knee of the patient, and rests his hand on a suitable support (*e.g.* a small stool and sandbag). With his other hand grasping the patient's ankle, the operator keeps the leg in a position of medial rotation. The leg is then levered upwards and medially, while an assistant holds down the pelvis. If the reduction is successful, the limb will thereafter be seen to lie in normal rotation, and any obvious shortening will have been corrected.

femur in a position of flexion and medial rotation, while an assistant holds down the pelvis. If the manipulation is successful, the limb will be seen to lie in normal rotation, and any obvious shortening will have been rectified. Continuous traction should thereafter be employed and the rotation controlled to prevent a recurrence of the deformity.

The operation.—This is best performed under local anaesthesia,

as the operative shock is then reduced to a minimum, and the surgeon is not so influenced by considerations of operative time in his attempt to secure the best possible alignment for the nail.

Suitable pre-medication is employed. *Omnopon gr.* 1/3 and *hyoscine gr.* 1/100 given one hour before operation (with repetition of the half dose where necessary) will be found to be very satisfactory.

Local anaesthesia.—This is induced while the patient is still on the bed or trolley. The soft tissues over the trochanter and upper two to three inches of the femoral shaft are infiltrated with ½ to 1 per cent. novocaine, 100 to 200 c.c. being injected. A point is now selected about 2 inches below the tip of the trochanter. A needle is entered at this point and passed along the *anterior* aspect of the neck of the bone in the general direction of the anterior superior spine of the opposite side. It is kept close to the surface of the bone, and at a depth of 3½ to 4 inches 20 c.c. of 2 per cent. novocaine are injected. The manoeuvre is now repeated

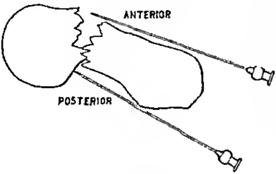


FIGURE 185

Outline of neck of femur in lateral view (section made in the plane of its axis). Note the position of the fragments before the lateral rotation has been corrected. The mode of injection of local anaesthetic is shown.

FIGURE 186

Injection of local anaesthetic. Needles in situ.

along the *posterior* surface of the neck, and a similar injection is made. (Figs. 185 and 186.)

Reduction of the fracture may now be carried out painlessly, by the method shown in Fig. 184.

Position of the patient on the orthopaedic table.—This is of primary importance in the "blind" operation of nailing. Two points require to be considered: firstly the position of the limb should be one which will secure the most accurate apposition of the fragments, and, secondly, guidance should be available as to the direction in which the axis of the femoral neck lies. Both requirements are satisfied by the following technique, modified from that of Noordenbos. In this method, the legs are widely abducted so that the distance between the two medial malleoli is equal to the distance between the anterior superior spine and malleolus. The axis of the femoral neck (antero-posterior view) now lies in a line drawn from a point $\frac{3}{4}$-inch below the base of the trochanter to the anterior superior spine of the opposite side (Fig. 187). In addition, the affected limb should be in a position of extreme medial rotation, in order that the fractured surfaces may be accurately opposed. For this it is necessary to rotate the limb medially until the foot is lying nearly horizontally. The limb should not be rotated simply by twisting the foot, or a spiral fracture of the lower leg may result. The rotation is gradually achieved by using the slightly flexed lower leg as a lever. When the necessary rotation is obtained, the knee is straightened and the foot fixed in position on the frame

FIGURE 187

Diagram to show the direction of the axis of the femoral neck, in the position of abduction described in the text.

A.—Anterior superior spine of opposite side.
B.—Transverse ridge at base of trochanter.

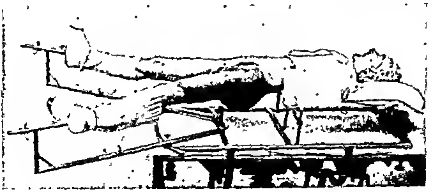


FIGURE 188

Patient placed on the Portable Traction Table in position for the nailing operation. (*See description in text.*) Note the extreme medial rotation of the affected leg. (The skin of the operation area has been painted with iodine.)

(Fig. 188). Where local anaesthesia alone is used, this extreme rotation causes some temporary discomfort to the patient, but, if the premedication is adequate, the discomfort lasts only for a few moments

after the leg has been fixed, and the patient remembers nothing of it afterwards. It is rarely possible to overdo the medial rotation: the fault is much more likely to lie in the other direction. The position of the fragments after insufficient medial rotation is seen in Fig. 185.

The amount of traction to be applied to the limb varies according to circumstances. If the shortening has previously been reduced, sufficient traction to steady the patient on the orthopaedic table is all that is required.

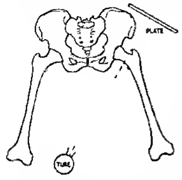


FIGURE 189

Method of obtaining lateral radiograph of neck of femur. Position of tube and plate.

Radiographs.—At least five films will require to be taken during the course of the operation. An antero-posterior and a lateral view should be taken at this stage to ensure that the reduction is accurate. For the lateral view, the tube is placed just inside the sound limb at about the level of the knee, and the plate is held pressed well into the loin just above the iliac crest (Fig. 189). While these films are being developed, the operation is commenced. If reduction of the fracture is shown to be faulty, further adjustments can be made later in regard to the position of the limb and the amount of traction

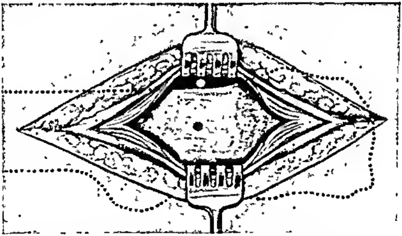


FIGURE 190

Exposure of the femur for the nailing operation. The fascia lata and vastus lateralis are incised and retracted. A hole is punched in the cortex ¾ in. below the base of the trochanter, and through this the guide is inserted *by hand*. The white spot indicates the position of the preliminary guide which is passed along the anterior surface of the bone. The main guide is kept parallel to this.

applied. Two further films, an antero-posterior and a lateral view, will be necessary to confirm the position of the guide, and a final antero-posterior view should show the nail in situ.

The incision begins at or just below the tip of the trochanter, and extends downwards in the line of the shaft for 2½ to 4 inches, depending on the amount of adipose tissue. The ilio-tibial tract with the posterior fibres of the tensor fasciae latae, and the vastus lateralis are divided, to expose the shaft of the femur in the lower part of the incision. A search is now made for the transverse ridge which marks the junction of trochanter and shaft. This is easily identified as being at the upper limit of the origin of the vastus lateralis.

Insertion of the wire guide.—The point for insertion of the guide lies on the *shaft* of the bone ¾-inch below the transverse ridge, and a hole the size of the guide is punched or drilled through the cortex. The guide is then inserted without difficulty by hand as its path lies entirely in cancellous bone. Standing *directly above* the guide, the operator aims it in the direction of the anterior superior spine of the

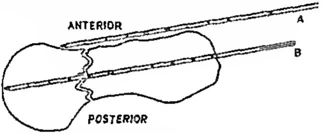


FIGURE 191

The displacement previously seen in a lateral view (Fig. 185) has now been corrected by extreme medial rotation. The plane of the anterior surface of the neck is parallel to its central axis, and a preliminary guide (A) is passed along this surface. The main guide (B) is kept parallel to it.

opposite side. At the same time the guide is kept parallel (under the direction of the assistant) with another guide which has previously been passed in the same line along the anterior surface of the neck of the bone (Fig. 191). It is of the greatest advantage to insert the guide *by hand*: any marked resistance encountered suggests that the point is against compact bone, and that the direction is at fault. The guide will be felt to cross the fracture before the slightly greater resistance of the head is encountered; it is finally arrested by the compact bone under the articular cartilage.

Antero-posterior and lateral radiographs are now taken, in order that the alignment of the guide may be determined, and nothing further can be done till these have been developed. The ideal is, of course, that the guide should be centrally placed in the axis of the neck in both antero-posterior and lateral views. A line slightly *below* the central axis is permissible, but no other position should be accepted. If the alignment is faulty, the direction of error should be estimated, and a fresh guide inserted until the position is above reproach. Much time is lost during the development of the radiographs after each attempt, but,

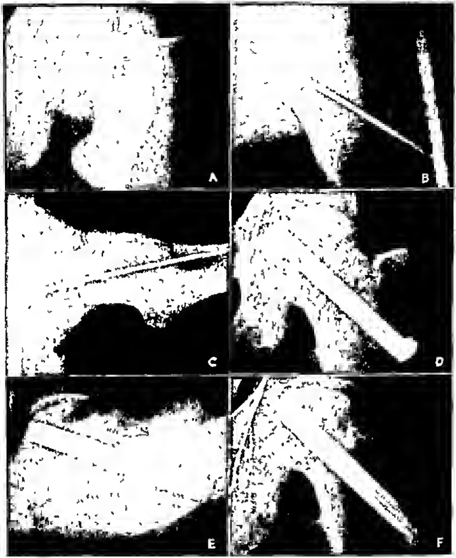


FIGURE 192

A.—Sub capital fracture—unreduced. *Note the upward displacement, and lateral rotation shown by the undue prominence of the lesser trochanter*

B.—Accurate reduction after traction and strong medial rotation. Satisfactory position of the wire guide. The measuring rod is also shown.

C.—Position of the guide confirmed in lateral view (taken as shown in Fig. 189)

D.—The nail in position. Its point lies ¼ in. from the articular surface (Patient is still on traction table, but limb is now in normal rotation.)

E.—Lateral view of nail in position (This view has been taken "antero-posteriorly," with thigh flexed to a right angle and slightly abducted.)

F.—The appearances six and a half months after operation. Union has occurred as shown by the bone trabeculation crossing the site of fracture.

under scopolamine-morphine narcosis and local anaesthesia, this is a matter of little concern to the patient, and is amply compensated for by the knowledge that a perfectly placed nail is the all-important factor in determining the after-treatment and prognosis.

In a few cases the degree of abduction demanded by Noordenbos's technique will be found to produce a coxa valga deformity. The abduction must then be reduced, and another method employed for obtaining correct alignment of the guide. A useful device is shown in Fig. 193. A Michel clip is placed on the skin over the highest point of the head of the femur, *i.e.* $\frac{1}{2}$-inch below the mid-inguinal point, and two or three other clips are placed at short intervals on each side of this, forming an arc facing downwards and laterally. A radiograph will then show the clip which most nearly overlies the axis of the neck, and will indicate the direction in which the guide should be inserted.

FIGURE 193

Method of obtaining correct alignment of the guide by the placing of a semicircle of Michel clips in the skin. The guide was aimed to pass in a line between the centre clip and the one immediately below. *(After Brittain)*

Insertion of the nail.—After the position of the wire guide is judged to be satisfactory, a nail of suitable length is chosen. This is estimated by the length of guide within the bone, which may be determined from the graduations upon it, or by subtracting the length of guide *outside* the bone from its total length. Alternatively the measuring rod may be used (see description to Plate XXIX). In its final position, the nail should stop $\frac{1}{4}$-inch short of the articular cartilage, and, in calculating the length of nail required, one should subtract another $\frac{1}{4}$-inch to allow for impaction of the fragments.

The nail is threaded on the guide, and is hammered home with the aid of the special punch, while an assistant presses on the other side of the pelvis. The hammer blows may appear to cause some discomfort, but, if the narcosis is adequate, the patient remembers nothing of it afterwards. A little gas may be administered if necessary, but this is rarely required. After the nail has been driven home, the fragments are impacted by the use of the impacting punch (Plate XXIX), by which the lower fragment is hammered along the nail, and any gap which exists between the fracture surfaces is closed. *The traction must be relaxed before this is attempted.* After impaction has been carried out, the nail will usually be found to project a little outside the shaft of the bone, and will require a final tap to drive it completely home.

Care must be taken not to break down the cortex by burying the head of the nail.

The position of the nail should be confirmed by a final radiograph before the patient leaves the table. (An antero-posterior view will suffice.) *During the development of this film, the wound is closed.* In stout patients, a small drain may be inserted, and left in for 48 hours. The radiograph will be available before the dressings are ready to be applied, and if any correction requires to be made, the wound can be rapidly reopened. If the nail has penetrated too far, it can be extracted for a short distance. Alternatively, where necessary, it may be driven in a little further, or more adequate impaction may be carried out.

After-treatment.—Complete bony union of the fracture probably does not occur until four to six months after the operation, but if the

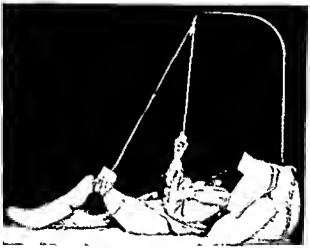


FIGURE 194

Post-operative exercises to ensure mobility at hip and knee joints. These may be commenced two or three days after the operation. (The sling is separately illustrated in Fig. 87.)

nailing has been successful, the fragments should be held in perfectly firm apposition. No retentive apparatus is therefore required after the patient's return to bed, and active movements are encouraged from the first. The exercise shown in Fig. 194 is particularly useful: with the aid of the sling the patient carries out "cycling" movements of the limb.

Weight-bearing.—On the principle that the fracture should be as firm the day after operation as it will be at any time until bony union has occurred, some surgeons allow the patient to walk without support in about a fortnight's time, *i.e.* as soon as the wound of the soft tissues has healed. For this, however, it is essential that the position of the nail should be above reproach: it should lie in the

central axis of the neck, and should penetrate sufficiently far into the head to secure a really firm hold, but its point should be at least ¼-inch from the articular surface. Frequent disappointments will result if early weight-bearing is allowed without these conditions having been fulfilled.

Where the position of the nail is less satisfactory, much greater care must be exercised, and no fixed rule can be laid down. Crutches should be used at first, and weight-bearing without support should not be allowed till there is radiological evidence of healing.

Removal of the nail.—The operation is still of too recent date to permit of any definite statement regarding the necessity of removing the nail. It is claimed that the nails at present made of non-magnetic stainless steel do not give rise to absorption of bone, so that, if in good position, they can be left indefinitely *in situ*. It is certain, however, that absorption is liable to occur if the nail is in faulty position, *i.e.* if it lies within ¼-inch of the bone surface—either of the neck or of the articular cortex.

Until bony union has taken place, the patient should be X-rayed regularly at four-weekly intervals. Any sign of bony absorption around the nail indicates that weight-bearing should at once be discontinued, and the patient kept at rest till consolidation has occurred. The nail may then require to be removed.

After the fracture has firmly united, the patient is told to report only if pain or discomfort is experienced. In a small proportion of cases, the nail works loose and becomes partially extruded. Its removal then offers no difficulty.

BASAL FRACTURES—PERTROCHANTERIC FRACTURES

Fractures through the base of the neck or through the trochanters fall into three main groups, according to the nature of the fracture and the presence or absence of impaction.

Incomplete or sub-periosteal fractures.—*These fractures may* be little more than a crack through the bone of the trochanteric region, so that displacement is usually absent. The appearances in an antero-posterior radiograph, however, may be deceptive, and a lateral view should always be taken, as there is a tendency for the fracture to open anteriorly, with resultant forward angulation of the neck.

Treatment.—In the less severe cases no fixation is required, but as there is a definite tendency to the development of coxa vara, weight-bearing should be prevented for several weeks by the use of crutches or by a walking caliper splint (Fig. 196). In cases where the fracture tends to be more complete, and especially if there is any suggestion of forward angulation of the neck of the bone, a short hip plaster should be applied, with the leg in the position of slight abduction and medial rotation (Fig. 195).

FIGURE 195

Short type of hip plaster cast, used in cases of sub periosteal or impacted basal fractures.

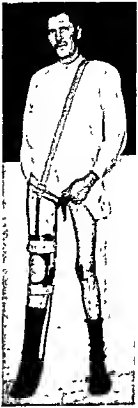


FIGURE 196

Thomas's walking caliper splint used in ambulant treatment.

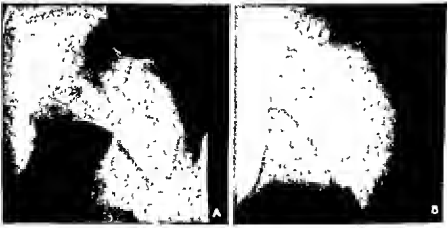


FIGURE 197

A.—Basal or pertrochanteric fracture without impaction. Considerable lateral rotation is present, as shown by the marked prominence of the lesser trochanter, but there is no upward displacement.
B.—The same case after reduction by the Whitman method (Fig. 198.)

Complete fractures without impaction.—When the fracture is complete and no impaction has occurred, considerable displacement is usually present. Lateral rotation of the limb may be especially pronounced, as, if the fracture is distal to the capsular attachment, the lower fragment is completely uncontrolled (Fig. 197). A varying degree of upward displacement is also present.

Treatment.—The most satisfactory treatment consists in the immobilization of the limb in plaster in a position of wide abduction and medial rotation (Whitman). Preliminary reduction is carried out on an orthopaedic table, traction being applied to the limb in the position described (Fig. 198). The plaster cast may be largely "unpadded," but felt pads should be incorporated—two strips 4 to 5 inches in width over the vertebral column and around the lower ribs, and two small squares over the anterior superior iliac spines.

If much upward displacement has occurred, it is better to apply continuous traction for a week or ten days before the Whitman plaster is fitted. The traction should be applied with the limb abducted and in a position of slight medial rotation if this can be accomplished. Skeletal traction has peculiar advantages in such cases, as the rotation of the limb can be much more effectively controlled.

Bony union of the fracture invariably occurs, but about three months' immobilization is usually necessary to guard against the development of coxa vara.

In the case of elderly patients and in others whose condition precludes the wearing of a Whitman plaster for that period of time, continuous traction should be employed throughout. The different methods of applying traction are described under fractures of the shaft of the femur.

In a definite proportion of basal fractures it will be found that the line of fracture extends obliquely downwards into the shaft of the bone, so that the lesser trochanter lies on the upper fragment. Alternatively the lesser trochanter may be completely avulsed as a separate fragment. In such cases the limb should be immobilized in a position of flexion at the hip joint in order to relax the pull of the ilio-psoas muscle.

Impacted fractures.—Impaction of the fragments is most liable to occur when the fracture is situated at the base of the neck at its junction with the trochanters. The neck is then driven into the cancellous bone of the trochanteric region (Fig. 200). The function of the limb is often surprisingly little impaired, but movements, especially abduction, are likely to be limited. On X-ray examination, the deformity may be seen to be slight, but varying degrees of shortening and lateral rotation are usually present.

Treatment depends upon the general condition of the patient, and on the amount of deformity present. In young healthy adults,

FIGURE 108

Reduction of a basal fracture of the neck of the femur, and application of plaster cast (Whitman's method).

A.—Patient in position on the Portable Traction Table (Plate XXXIV). The limb is fixed in abduction and medial rotation, and screw traction is applied—the amount depending on the degree of upward displacement.

B.—Felt pads in position. One strip is placed round the lower ribs, and a small square over each anterior superior spine. In addition, a long felt pad 4 in. wide is placed posteriorly over the spine and sacrum.

C.—The plaster cast completed down to the ankle. It is extended over the foot after this has been detached from the foot-piece of the table. The knee is fixed in a slightly flexed position. An abdominal window is provided.

unless the deformity is very slight, the fracture should usually be disimpacted. This is best carried out by the method described for the reduction of sub-capital fractures (Fig. 184), and the patient should thereafter be treated in a Whitman plaster (Fig. 199), with or without a preliminary period of continuous traction.

In elderly patients, much greater circumspection is required. It must be remembered that a firmly impacted fracture is well established on the way towards bony union, and that, unless the deformity is such as will prevent reasonable function, the surgeon takes a great responsibility in disimpacting the fragments, as a long

FIGURE 199

Whitman plaster cast complete. Note the position of abduction and medial rotation at the hip joint, and slight flexion at the knee.

period of immobilization will then be required. The conservative treatment of a firmly impacted fracture may involve no more than the prevention of weight-bearing for six to twelve weeks, and the employment of massage and exercises from the outset. If the impaction is judged to be insufficiently secure to permit of free movement, a short plaster cast of the type shown in Fig. 195 may be employed for a few weeks during which time the patient is kept at rest. Elderly patients cannot safely be allowed to use crutches.

Nailing operation in basal fractures.—In a certain number of basal and pertrochanteric fractures it may be possible to secure fixation of the fragments by means of a Smith Petersen nail. It is essential that the upper end of the distal fragment should be sufficiently broad for the nail to secure a firm hold. With this end in view,

the nail should be inserted at a much more oblique angle than in sub-capital fractures (Stirling). The operation is particularly suitable

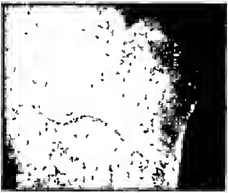


FIGURE 200

Basal fracture of the neck of the femur with firm impaction of the fragments. Considerable shortening and coxa vara are present, but only a moderate degree of lateral rotation.

for non-impacted fractures in old people, as the necessity for prolonged immobilization will then be avoided, and freedom of movement can be allowed from the outset. The hold of the nail on the lower frag-

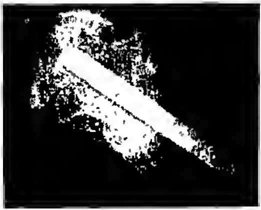


FIGURE 201

Basal fracture of the neck of the femur treated with a Smith Petersen nail. Note that the nail is inserted at an angle entirely different from that advised for sub-capital fractures. (Compare with Fig. 19?)

ment, however, is liable to be somewhat insecure, and weight-bearing should be permitted with caution, owing to the danger of coxa vara developing before union is firm.

XVI

FRACTURES OF THE SHAFT OF THE FEMUR

IN all types of fracture of the shaft of the femur, shortening is invariably present, due to over-riding of the fragments. Traction is required not only to undo this over-riding and to secure apposition of the fragments, but also to maintain the position after reduction has been effected. The femur is so thickly padded with muscles, that in the absence of traction no splint or plaster cast, even if carried up on to the trunk, can provide adequate control of the fragments, and re-displacement will always tend to occur. Any splint or plaster cast applied during the early stages of treatment serves mainly as a support to the limb during the maintenance of the traction. It also determines the general position of the limb in relation to flexion at hip and knee joints, and it prevents sagging at the fracture site with consequent backward angulation. *It will have little or no effect in procuring true immobilization of the fragments.*

If the splint or plaster cast can be suspended clear of the bed by counter-balancing weights, the patient's comfort will be greatly increased, as the limb can then be moved without effort as he changes position in bed, and without the same risk of displacement of the fragments. The circulation of the limb as a whole is improved, and swelling is more rapidly alleviated.

TRACTION METHODS

Skin traction.—This is obtained by two strips of adhesive material or "traction strapping" affixed to the skin, one on each side of the limb. Many brands of such strapping are available. Strong holland material backed with glue has been used for many years. A suitable width is 9 inches, for in this the two strips can be conveniently obtained from one length of material if this is cut obliquely (Fig. 202). The distal end of the strip must always be narrow (not more than $2\frac{1}{4}$ inches in width), but it is of advantage to have the strapping broader in its upper part as a firmer hold will then be obtained. Overlapping of the strips should be avoided—especially on the anterior aspect of the limb. Cuts may be made into the strap-

FIGURE 202

Diagram to show method of cutting the *traction strapping, so that the two strips* may be obtained from one length of material.

ping so that it will lie more evenly on the leg (Fig. 203). Webbing tapes are sewn on to the lower ends, or the strips may be cut longer and the distal part folded to form a strap. Holland strapping is usually made more adhesive by warming or by moistening with turpentine. It is then applied to the shaved skin along the *whole* length of the limb.

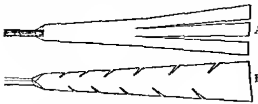


FIGURE 203

Alternative methods of cutting the strapping so that it may lie evenly on the limb. A webbing tape may be sewn on to the lower end (A), or the strapping may be folded (B).

In the application of *traction strapping* certain precautions are very essential. *On no account should the strips meet or overlap on the front of the ankle region*, as the most devastating pressure sores are then liable to result, when the inevitable slipping of the strapping takes place. Pads of felt or wool should be placed between the strapping and the malleoli, where the skin is intolerant of pressure. The strapping is secured with a soft encircling bandage; *this should start a hand's breadth above the ankle joint, or pressure sores may be caused.* Circular turns of adhesive strapping should not be used, for they may cut into the skin as slipping occurs.

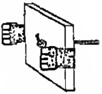


FIGURE 204

Wooden "spreader" for use with skin traction.

Skin traction is most successful in cases where *fixed traction* is to be employed. For continuous traction the method is less satisfactory, for if adequate weight is applied the strapping tends to slip, and may require to be reapplied at intervals of two or three weeks. Some skin irritation is frequently caused, and occasionally, in spite of all precautions, actual excoriation results. The method has however many advantages over skeletal traction, in that there is no danger of bone infection, and there is less likelihood of stiffness of the knee joint afterwards.

Of recent years, several proprietary brands of traction strapping have become available, *e.g.* *"Flexoplast" orthopaedic strapping.* This is non-expansile longitudinally but stretches in width, so that it adheres very snugly round the limb. Such strapping is less irritating to the skin and secures a relatively firm hold. In certain individuals, however, skin irritation is always liable to occur. The same precautions must be observed in regard to overlapping of the strapping in front.

Skeletal traction.—This term is used to designate traction applied *directly* to the bone by means of special instruments (Plate XXX). In cases of fractured femur, three sites are available for its application,—the condyles, the shaft immediately above the condyles, and the tuberosity of the tibia. Of these, the condyles are the least suitable

choice, and should only be used where ice-tong calipers alone are available. It is an undoubted fact that the application of such calipers to the condyles tends to cause knee stiffness afterwards, probably by the production of an irritative reaction at the ligamentous attachments. Also, the danger of the points of the calipers slipping into the knee joint cannot be disregarded. The supra-condylar region and the tibial tuberosity are more satisfactory sites for application of the traction. With the former, a more direct pull is obtained on the femur, and certain displacements, particularly that of backward angulation, may be more easily corrected; with the latter, there is

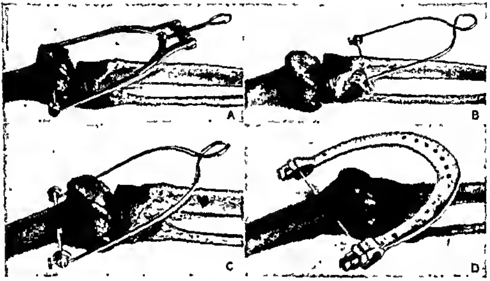


FIGURE 205

Appliances used for obtaining skeletal traction on the femur, and sites of their application.

B.—Ice-tong calipers applied to the condyles of the femur.
A.—Pin with rotating stirrup applied to tibial tuberosity.
C.—Pin with rotating stirrup applied above the condyles.
D.—Kirschner wire applied to femur above the condyles.

certainly less tendency to knee stiffness, and the joint does not appear to suffer in any way from the traction. The Kirschner wire is probably most suitable for use in the supra-condylar region, and the pin and rotating stirrup for the tibial tuberosity. The different appliances used for obtaining traction in cases of fractured femur and the sites of their application are illustrated in Fig. 205.

Skeletal traction has very definite advantages over skin traction in that a much stronger pull can be continuously maintained without risk of slipping, and the rotation of the lower fragment, together with the limb as a whole, is more effectively controlled. The risk of producing bone sepsis is relatively slight, if adequate precautions are observed, but the traction should not be applied in proximity to any skin abrasions or to other potentially septic foci.

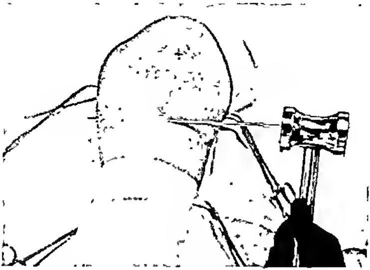


FIGURE 206

Insertion of pin through tuberosity of tibia. The pin is inserted from the lateral side, and may be either hammered or drilled through the bone

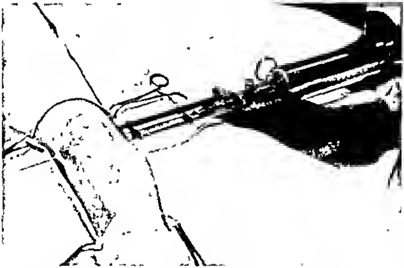


FIGURE 207

Insertion of Kirschner wire through the supra-condylar region The wire is drilled through from the medial side. A point 1 in. above and ½ in. in front of the adductor tubercle is selected. (The electric drill with telescopic attachment is also shown in Plate XXXVII.)

"Fixed" traction.—In this type of traction the pull is applied to the limb against a fixed point of counter-pressure. In the old method of treatment by a Liston's long splint, the foot was pulled down towards the end of the splint, while counter-traction was obtained by a perineal band tied to the other end. At the present time, fixed traction is usually carried out in a Thomas's splint, the padded ring of which provides counter-pressure against the ischial tuberosity. This method of obtaining fixed traction is fully described in the section dealing with the use of Thomas's splint (p. 178).

Continuous traction.—By this method the pull is exerted by means of weights attached to the limb, either through the medium of skin strapping, or applied directly to the bone (skeletal traction). *It should be noted that there is no point of counter-pressure: the pull is counter-balanced by the patient's own weight, and in order that this may be effective the foot of the bed should always be raised.* The elevation required varies with the type of splint used, and with the amount of traction employed.

Amount of traction.—It is most essential that adequate traction should be applied in order that the shortening should be completely corrected. In cases of transverse fracture, persistent lateral displacement of the fragments is frequently due to an insufficient pull, as the slightest degree of over-riding will obviously prevent end-to-end apposition. On the other hand over-distraction must be carefully avoided, as separation of the fragments, even for a short time, will allow the inter-position of soft parts between the fracture surfaces, and delayed union will almost certainly result.

It is a useful rule to apply in the first instance a weight equal to *one-seventh of the body weight, i.e. 2 lbs. per stone.* It should be emphasized, however, that no fixed rule can be laid down, as the traction required will vary according to the type of fracture, and the muscularity of the individual. In the case of transverse fractures, a much greater weight will often be necessary to allow the fragments to slip into apposition, but it will subsequently require to be reduced, if over-distraction is to be avoided. All patients should be X-rayed twenty-four to forty-eight hours after the traction is set up, and the weight readjusted if necessary. If the weight is being used to *suspend* the splint as well as to provide traction (*i.e.* on the Hodgen principle), it must be correspondingly increased.

Direction of traction and position of the limb.—Emphasis is usually laid on the importance of distinguishing between fractures at the different levels of the shaft of the femur, in determining the position in which the limb should be put up, and the direction in which traction should be applied.

In fractures of the upper third, the small and uncontrollable upper fragment is likely to be *flexed, abducted and laterally rotated* by the action of the ilio-psoas and glutei muscles, so that, in order to bring

the lower fragment into line, the limb should be put up, and the traction maintained, with the thigh in this position.

In fractures of the middle third, no special importance is attached to the position of the limb, but the fracture site must be well supported to prevent backward angulation, which will tend to occur if the slings are allowed to become slack.

Fractures of the lower third and supra-condylar fractures require special consideration, as, owing to the pull of the gastrocnemius muscle, the small lower fragment is usually tilted backwards. It is advised, therefore, that such fractures should be treated *with both hip and knee joints flexed,* in which position the fragments are brought into alignment (Fig. 208).

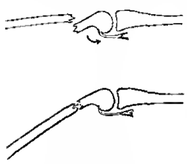


FIGURE 208

Drawing to show how, in supra-condylar fractures, the small lower fragment is tilted backwards by the action of the gastrocnemius muscle. The displacement is corrected when the hip and knee joints are flexed

In general, however, it will be found very satisfactory to treat *all* fractures of the femoral shaft in flexion at both hip and knee joints. In this position, the leg can be more easily suspended clear of the bed, and knee stiffness is less likely to result from prolonged immobilization.

Difficulties in reduction.—The first radiograph taken after the fracture has been put up may frequently come as a painful surprise to the operator, as considerable displacement is sometimes shown to remain, when clinical examination had suggested that the alignment was satisfactory. It should always be possible, however, by appropriate measures to correct any marked deformity, although one cannot always be successful in securing accurate end-to-end apposition. Often the traction will be shown to have been inadequate, and the displacement may immediately disappear if the pull is increased. In other cases, the fault may lie in the position of the limb: increased flexion of the thigh in fractures of the upper third, or of the leg, in supra-condylar fractures, may bring about the desired improvement. The tightening of a sling or the placing of a pad of wool below one fragment may be equally effective. Much can also be done by altering the direction of the traction. Mechanical fixation by open operation should only be considered in fractures of the femoral shaft, when all conservative measures have been unsuccessful, and it is probably to be regarded as a confession of failure. It should be remembered that accurate end-to-end apposition of the fracture, however desirable is by no means essential to a good functional result, but shortening must be reduced to a minimum. *The question of alignment is however of primary importance;* apart from the local deformity, a fracture which

has healed with angulation is very liable at a later date to lead to static disturbance in the knee joint, as the result of the abnormal stresses to which the joint is subjected.

After-treatment.—Traction is essential for a minimum of five to six weeks, and is usually maintained for longer periods. It should be gradually relaxed, as there is radiological evidence of consolidation. After traction has been discontinued, the limb may be retained in the splint to prevent possible angulation at the site of the soft callus, or a plaster cast (which should include the trunk) may be applied, in which case the patient can be discharged home.

Knee movements.—With certain splints and methods of traction, movements of flexion and extension of the knee may be carried out from the first, but the value of this is doubtful, as in the early stages movement at the fracture site is liable to result. In any case, not more than 30 to 45 degrees of movement is normally possible during the application of the traction, and it is questionable whether a wider range of movement is obtained any earlier than in cases where complete immobilization is maintained until the fracture has firmly healed. If the knee is immobilized in flexion, the chances of subsequent stiffness are not very great, but the patient should be instructed from the first to carry out "quadriceps exercises" (*e.g.* upward jerking of the patella). This can be done quite easily even under a plaster cast.

FIGURE 209
A Thomas's walking caliper splint.

Prevention of "drop-foot."—Drop-foot is particularly liable to occur in older patients, and a careful watch should be kept for its development. The ankle joint may be fixed at a right angle from the outset; alternatively the patient is instructed to move the joint freely, and fixation is carried out only if weakness of the dorsi-flexor muscles becomes apparent. A serious form of drop-foot, due to paralysis of the lateral popliteal nerve, may result from the pressure of a sling on the back of the head of the fibula.

Weight-bearing.—It is an old maxim that weight-bearing *without support* should not be allowed for 100 days after the accident, but in many cases the fracture is perfectly firm on clinical and radiological examination after eight to ten weeks. It is better to err on the safe side, however, as re-fracture is not uncommon. A walking caliper splint (Figs. 196 and 209) may be worn for several weeks before full weight-bearing is allowed.

THOMAS'S BED (KNEE) SPLINT

This splint (see also Plate XXXII) is probably the most widely used of all appliances in the *treatment of fractured femur*. *It can be employed* for either fixed or continuous traction.

Fixed traction.—It was for this type of traction that Thomas's splint was originally designed, and for which it is most essentially suited. *The traction* is obtained by means of skin strapping, which is pulled down and tied to the end of the *splint*. A "*spreader*" (Fig. 204) may be used, or the extensions from the strapping may be brought round the sides of the splint before being tied, in the manner shown in Fig. 210. *Counter-pressure is obtained* by the push of the padded ring against the ischial tuberosity, and in order that this should be *effective*, *an accurately fitting ring is very essential*. If the ring is too large, it will slip up over the tuberosity, so that the pressure will come to be taken on the perineum. The limb is supported

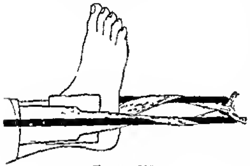


FIGURE 210

Method of obtaining fixed traction in a Thomas's splint, without the use of a spreader. Extensions from the strapping are brought round the side bars before being tied

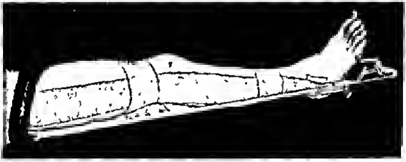


FIGURE 211

Fixed traction in a straight Thomas's splint.

Note that the malleoli are protected by felt pads, that the heel is left free, and that no overlapping of the strapping occurs on the front of the ankle region. A large pad of wool is placed below the knee. (This has been omitted from the photograph for the sake of clearness.) It is advised that the traction strapping should be secured to the limb by a soft bandage, and not, as shown here, by circular turns of adhesive strapping.

in the splint by means of *flannel slings* passed *between the two side* bars. Each sling is adjusted separately, *after* the limb is in the splint, and is secured with a special clip or with at least two safety

pins. Alternatively, a gutter splint extending from the upper thigh to below the calf may be employed. This can be supported by two slings, one at each end. To avoid the development of pressure sores, the posterior surface of the heel must be well protected by wool, or alternatively, no sling may be placed there at all, the heel being left entirely free (Figs. 212 and 213). A large pad of wool is placed behind the knee, to maintain the joint in 5 to 10 degrees of flexion.

As the muscular spasm is gradually overcome, tension on the strapping is reduced, and the slack must be taken up at frequent intervals, until all shortening has been corrected. *On no account must an elastic pull be exerted towards the end of the splint, e.g.* by a spring

Figure 212

Fixed traction in a Thomas's splint bent at the knee.

This method is useful in fractures of the lower third of the femur, where it is advisable that both hip and knee joints should be flexed. The support for the distal end of the splint is combined with a foot-piece which maintains dorsi-flexion at the ankle.

or stretched rubber tubing, or pressure sores will rapidly result at the points of contact of the ring. After shortening has been corrected, the traction tapes will require to be tightened only when slipping of the strapping occurs; this depends upon the quality of the strapping and on the care with which it has been applied. The slings require constant attention, as they tend to work loose, and to allow sagging of the limb at the site of fracture. This may be prevented by the use of the posterior gutter splint already described.

It is often preferable to employ a Thomas's splint which has been bent at the level of the knee joint. This is of special advantage in fractures of the lower third of the shaft of the femur, as flexion at both hip and knee joints can be obtained (see p. 176). The distal end of the splint may be supported by the special attachment shown in Fig. 212. This attachment is conveniently combined with a foot-piece, which maintains dorsi-flexion of the ankle. Alternatively

the splint may be suspended clear of the bed by counter-balancing weights, or by slinging it from a pulley in the manner illustrated in Fig. 213. The patient can then move about in bed with greater freedom, and the use of the bed pan is attended with much less discomfort. *If the splint rests entirely on the bed, the patient tends to remain anchored in one position.*

Continuous traction.—The simplest way of obtaining continuous traction in a Thomas's splint is to fasten the end of the splint to the foot of the bed, which is raised on blocks. The traction is

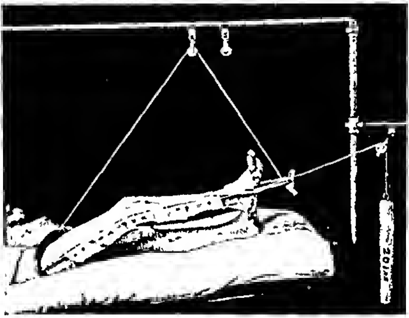


FIGURE 213

Satisfactory method of obtaining *continuous* traction in a Thomas's splint. *Fixed* traction is first carried out to the end of the splint, which is bent opposite the knee. A weight is then attached *to the splint*, which is suspended *clear of the bed. The foot of the bed is raised to provide counter-traction.*

increased by the weight of the patient, and is unaffected by slight *slipping of the strapping. In addition, the pressure of the ring* against the ischial tuberosity is reduced.

A more satisfactory method is to suspend the splint clear of the bed, and to attach a weight which will exert a pull in the line of the limb (Fig. 213). *It is preferable that the weight should be attached, not to the leg, but to the splint.* By this method the limb is not being pulled into a stationary splint, but the limb *and splint* are being pulled down together against the counter-traction of the patient's own weight. The splint therefore acts merely as a support for the limb, and does not provide counter-pressure. The effect of the traction is actually to pull the ring *away* from the ischial tuberosity. This method gives

much greater comfort to the patient. He enjoys a relative freedom of movement in bed, as he is able without assistance to change his position in all directions, and, from the first, can lift himself easily for nursing purposes. As in all methods of applying continuous traction, it is essential that the foot of the bed should be raised.

Skeletal traction.—The pull may be obtained by means of a wire or pin passed through the femur above the condyles or through the tibial tuberosity. A "*flexion-piece*" should be attached to the splint, as traction is more easily applied with the knee flexed; it also allows movements of the knee during treatment. The splint is suspended clear of the bed, and the flexion-piece is arranged so that the lower

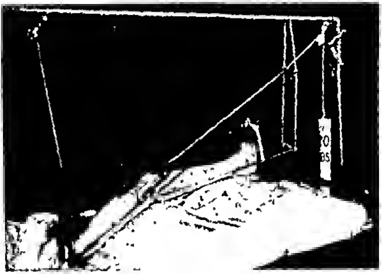


FIGURE 214

Skeletal traction in a Thomas's splint fitted with a flexion-piece. Traction is maintained in the line of the femur by means of a Kirschner wire passed through the supra-condylar region. The flexion-piece is arranged so that the lower leg is horizontal; it is fitted with a foot-piece which keeps the foot dorsi flexed to a right angle. This method of treatment allows movement at the knee joint during the application of traction.

leg is horizontal (Fig. 214). Traction is usually applied in the line of the femur, but, in supra-condylar fractures, the pull is exerted more horizontally, and the hinge of the flexion-piece is placed under the site of fracture, so that backward angulation may be corrected (see Figs. 222 and 223). As before, it should be noted that *the limb is not being pulled into a stationary splint*; the splint can slide up and down the bed with the patient, and acts merely as a support to the limb. The padded ring of the splint has little function—counter-traction is provided by the patient's own weight, and the foot of the bed is therefore raised.

This method of treatment enjoys considerable popularity; skeletal traction has certain advantages which have already been dis-

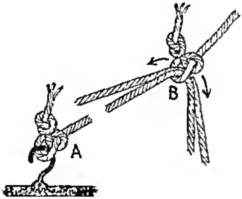


FIGURE 215

Attachment of ropes for the suspension of a Hodgen's splint.

A.—Method by which rope slings are attached to each of the four hooks.

B.—Slip knot by which the rope bearing the weight is attached to the slings. It can be slid in either direction along the slings according to the angle at which traction is applied.

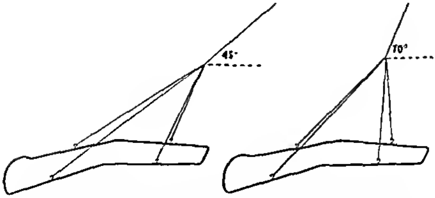


FIGURE 216

Drawing to show how the amount of traction may be varied according to the angle at which the splint is suspended. The slip knot is slid along the slings (Fig. 215 B), so as to keep the splint balanced with the lower leg horizontal.

cussed, and movements of the knee joint can be carried out during treatment. Such movement may be allowed after the first two or three weeks; a rope attached to the flexion-piece is passed over a pulley, and given to the patient; with this he can move the knee through a range of about 45 degrees. The value of such exercises is doubtful, however. If we accept the present-day view that joint stiffness after fractures is due mainly to changes in the muscles, such *passive* exercises can have little value, and may actually delay union of the fracture. The prevention of knee stiffness after fractured femur is discussed on page 177.

HODGEN'S SPLINT

This splint (see also Plate XXXII) bears some resemblance to the Thomas's splint, but it has only "half a ring" at its upper end, and this is unpadded. The side bars, which are slightly bent at the level of the knee joint, have each two small hooks attached, and in addition they may be joined together by two arches or cross-bars placed above and below the knee.

The splint itself provides no counter-pressure; it is merely a cradle in which the limb is suspended. As, however, the limb is secured by some form of traction to the splint, traction applied to the splint is communicated equally to the limb. The foot of the bed is raised to provide counter-traction. The traction is carried out at an angle of upwards of 45 degrees to the horizontal, so that its effect is "*half lift—half pull.*" By the action of a single weight, therefore, the limb is suspended clear of the bed, as well as being pulled in a longitudinal direction. It is found that this upward thrust is of service in preserving the normal anterior bowing of the femur.

Technique of application.—*Skin traction* is usually employed, and is carried out in the manner described on p. 171. If *skeletal traction* is desired, a rigid pin is passed through the femur above the condyles or through the tibial tuberosity (Fig. 206).

The splint is then laid along the *anterior* surface of the limb, and flannel slings are arranged posteriorly between the side bars. The heel should be well protected with wool. If skin traction is being carried out, a "spreader" may be used, or the strapping may be carried round the sides of the splint before being tied to the end (Figs. 204 and 210). When a transfixion pin is used, its ends are attached to the splint—either to one of the cross-bars or to the distal pair of hooks.

Two pieces of rope about 4 feet long are cut, and each is attached by its ends to the hooks on the *same* side of the splint. These form slings, by which the splint is suspended. In order that the splint may lie "on an even keel," it is important that these rope slings should be of the same length. This can be assured by cutting ropes of exactly

equal length at the beginning, and by placing knots at the same distance (say 1 inch) from the end of each. They are then secured to the hooks in the manner shown in Fig. 215 A. A third rope, to which the weight is attached, is now passed round the two slings in the form of a slip-knot (Fig. 215 B).

The direction of the pull varies from 45 to 70 degrees above the horizontal, according to the amount of traction desired. If a stronger pull is required, the angle is reduced, when additional weight will be necessary to keep the leg suspended. Conversely, a small weight pulling more vertically provides less longitudinal traction, but is

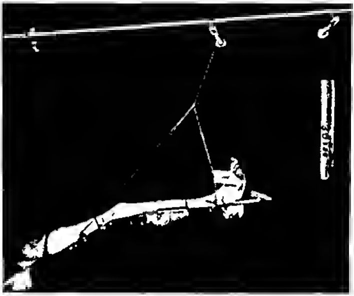


FIGURE 217

Hodgen's splint applied in the treatment of fractured femur.
(For description, see text.)

adequate for the suspension. The rope to which the weight is attached can be slid along the slings, in order that the splint may be balanced with the lower leg horizontal: such adjustments will be necessary, whenever the angle of traction is altered. The upper cross-bar of the splint should ride well clear of the skin of the groin. If pressure occurs, the cross-bar should not be padded, for this betrays a lack of understanding of the Hodgen principle—the slip knot should merely be slid a little proximally along the slings.

Amount of weight.—As the one pull serves to suspend the limb as well as to provide longitudinal traction, considerably more weight must be applied than when the latter is the only consideration. No rule can of course be laid down, but $2\frac{1}{2}$ *to 3 lbs. per stone of body weight* may be suggested as a useful guide.

"RUSSELL TRACTION"

Hamilton Russell has devised a method for applying traction to the femur, and at the same time supporting the limb in a position of flexion at both hip and knee joints, without the necessity of a splint or other apparatus. By means of an ingenious yet simple arrangement of pulleys, traction is applied both longitudinally and in an upward direction. The resultant of these two separate forces is dependent upon the law of the "*parallelogram of forces*" and can be shown to lie in the line of the femur.

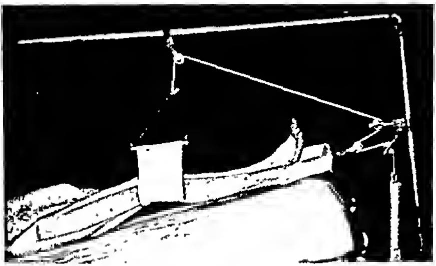


FIGURE 218

Hamilton Russell's method of continuous traction.

The sling which supports the knee is attached at each end to a wooden spreader; this prevents it from becoming bunched up and causing irritation of the skin. Note the arrangement of the four pulleys required. For the sake of clearness, the pillow which should support the limb has been omitted.

Horizontal traction is secured by skin strapping applied in the usual manner. The upward pull is obtained by means of a sling placed under the knee. From the sling a rope is carried round four pulleys arranged in the manner shown in Fig. 218. The first pulley should be placed above the upper third of the tibia, so that the direction of the upward pull is slightly distal to the vertical. Instead of the two pulleys attached to the upright of the frame, a double pulley may be used. The foot of the bed is raised to provide counter-traction. The mechanics of "Russell traction" are shown diagrammatically in Fig. 219.

The lower leg and knee rest on a pillow which is placed so that its upper part also provides support under the fracture. Frequent adjustments are required, as if the patient slides down in bed the angle of traction is altered. If backward angulation at the fracture

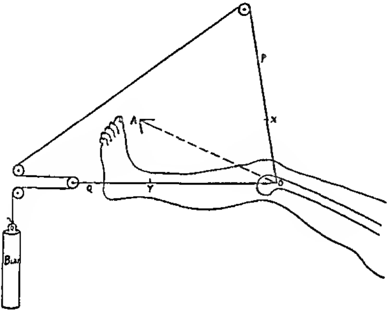


FIGURE 219

Diagram to show the mechanics of " Russell Traction."

It will be seen that there are two forces acting at the point O where the traction exerted can be regarded as taking effect—a more or less vertical pull in the line O P, and a horizontal pull in the line O Q. The resultant of this combination can be calculated from the law of the *parallelogram of forces, which states that if the two forces be represented in magnitude and direction* by the sides of a parallelogram, their resultant is similarly represented by the diagonal of that parallelogram.

If 8 lbs. weight is attached, the pull exerted in the line O P is 8 lbs. (The friction of the pulleys is disregarded.) But the pull in the line O Q is doubled, as it is carried out by means of a *double pulley system* (i.e. it is 16 lbs.). Let us therefore mark out on the line O P a distance O X, which will correspond to the magnitude of the pull—say, 16 mm., on the scale of 2 mm. to 1 lb. A distance O Y, equal to twice O X (i.e. 32 mm.) is marked out on the line O Q. If we now complete the parallelogram O X A Y, we see that its diagonal (representing the direction of the resultant force) lies in the line of the femur. This diagonal measures 38 mm., and on the scale used, this represents a pull of 19 lbs.

In these calculations the force of gravity is disregarded, as the limb should be supported to a great extent by the pillow on which it rests.

should occur, the direction of the resultant pull of the two forces can be lowered by sliding the top pulley distally.

There may be some difficulty in controlling the rotation of the limb, and there is a tendency for the sling to become displaced or to cause irritation of the skin behind the knee. These difficulties may be overcome if the method is modified so that skeletal traction

can be employed. This may be carried out in the manner illustrated in Fig. 220. A Kirschner wire is passed through the bone just above the condyles. From the ends of the stirrup two ropes are carried down, one on each side of the leg; they are separated by a spreader just beyond the heel, and are then attached to a pulley. The lower leg is supported by slings of bandage passed between the two ropes. Traction is applied in the manner shown.

"Russell traction" is particularly suitable for the treatment of fractures of the neck of the femur, or of the upper third of the shaft,

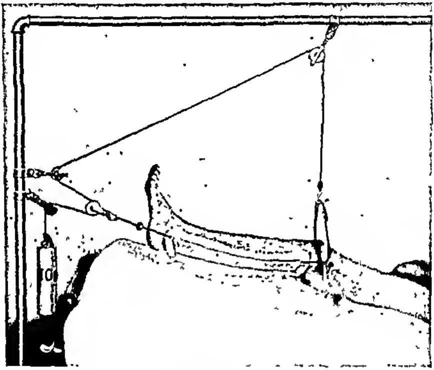


Figure 220

Method of Russell modified for use with skeletal traction.

A Kirschner wire is passed through the femur above the condyles. From the ends of the stirrup two ropes are carried down, one on each side of the leg; they are separated by a spreader just beyond the heel and are then attached to a pulley. The lower leg is supported by slings of bandage passed between these two ropes. Note that the patient has slipped down the bed and the upward pull, as shown, is in too vertical a direction. The pillow which supports the limb has been omitted.

as the position of flexion at the hip is satisfactorily maintained, and (by the skeletal method) the rotation of the limb is effectively controlled. In fractures of the lower two-thirds of the shaft, it is perhaps less satisfactory, as in the absence of a firm support, sagging at the fracture is liable to occur. The support provided by the pillow is adequate only if constant supervision and adjustment are carried out.

TREATMENT BY BÖHLER'S METHODS

Böhler treats fractures of the femur by means of splints on which the limb can be laid with both hip and knee joints in a flexed position. The thigh lies on an inclined plane, while the lower leg is horizontal, and with the limb in this position, traction is applied in or slightly below the line of the femur.

Bohler's lower leg splint (see also Plate XXXII).—This is modelled on Braun's splint, but has the additional provision of a pulley by which

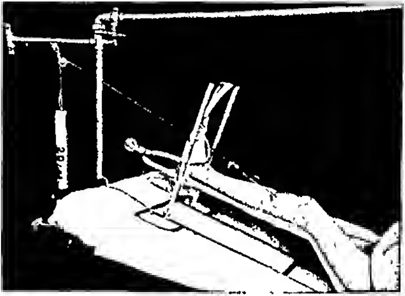


FIGURE 221

Treatment of supra-condylar fracture of the femur in Böhler's lower leg splint, used in conjunction with an overhead frame. For this fracture the angle of the splint lies not at the knee but *at the site of fracture*. Traction is applied in a line considerably lower than that of the femur so that backward angulation may be corrected (Fig. 223). The bed is raised 12 to 18 ins.

traction can be applied to the lower leg. Although designed for the treatment of lower leg fractures, this splint, when used in conjunction with an overhead frame, is equally useful for treating fractures of the femur.

Skeletal traction is obtained by means of a pin or wire passed through the tuberosity of the tibia (Fig. 205 B), and the leg is laid on the splint, which is carefully bandaged as shown in Fig. 254. Traction is then applied in or *slightly below* the line of the femur, by means of a rope passing over a pulley attached to the frame. Counter-traction is provided by the patient's own weight, and for this the foot of the bed is raised. The splint is tied to the foot of the bed to prevent it slipping down the incline, and a wooden block or box is placed in

the bed for the foot of the sound leg to rest against. Dorsi-flexion of the foot on the affected side is maintained by strapping, which is applied to the sole and is attached to the upper part of the splint; alternatively a weight may be attached by a rope passing over another pulley. This prevents not only foot-drop, but also lateral rotation of the limb, which otherwise is liable to occur: in addition, it reduces the risk of a pressure sore developing under the heel.

In fractures of the upper third of the shaft of the femur, the splint is placed obliquely in the bed so that the limb lies in the abducted

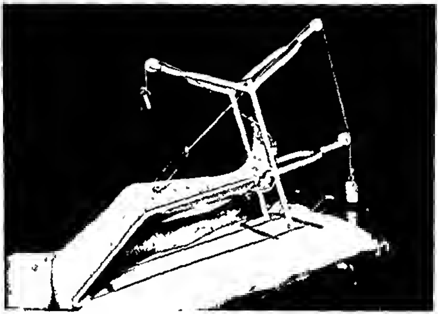


FIGURE 222

Böhler's femur splint in use. In this case, one of fracture of the mid-shaft, the angle of the splint is placed below the knee, and traction is carried out in the line of the femur. Note how the most proximal pulley can be used for maintaining dorsi-flexion of the foot. In some splints, a fourth pulley is provided for traction at a lower level.

position. The overhead frame is also arranged for the application of traction in this line.

In supra-condylar fractures, the lower fragment is almost invariably tilted, so that an angle pointing backwards is produced. For the correction of this deformity two special measures require to be taken—the splint should be moved proximally, or a splint with a shorter incline used, *so that the angle lies not at the knee but at the site of fracture*; at the same time, the direction of traction is lowered. The combined effect of these manoeuvres is that the thigh is now pulled over the bend of the splint, and the backward angulation is thus corrected (Figs. 221 and 223).

Böhler's femur splint.—In this splint (Plate XXXII) the principles

of treatment are exactly the same, except that the necessary pulleys are attached to the splint itself, and an overhead frame is not required. One pulley is placed in line with the inclined plane, and therefore in line with the femur: a second pulley may also be provided for traction at a lower angle, as in the treatment of supra-condylar fractures. Two further pulleys are available for traction on the lower leg and for suspending the foot.

In general, this splint is probably less satisfactory than the lower leg splint used in conjunction with an overhead frame, as, even with the choice of two pulleys for the femur traction, the same latitude is not available for varying the angle to suit the requirements of the individual case.

Anyone who has had the privilege of visiting Professor Böhler's clinic in Vienna cannot fail to be impressed by the excellence of the results obtained by these methods of treatment. If in other hands his

FIGURE 223

Supra-condylar fracture treated on Böhler's splint. If the angle of the splint is placed under the knee and traction is carried out in the line of the femur, backward tilting of the small fragment will be uncorrected. The deformity is reduced by placing the angle of the splint *below the fracture*, and by applying the traction in a more horizontal line.

methods have proved less satisfactory, this may be due largely to the neglect of certain precautions which Böhler describes as being essential for the efficient functioning of the splint. It is often complained that the inner angle of the splint causes pressure on the perineum. This is usually due to the fact that the lower end of the bed has not been sufficiently raised; it is a common fault to use blocks of only 6 or 8 inches in height, whereas a minimum of 12 inches is absolutely essential. In some cases the bed must be raised 18 to 20 inches (*i.e.* to the height of an ordinary chair). By such methods, and by the provision of a support against which the sound foot may rest, pressure on the perineum can usually be prevented. Böhler advises that a special scissors-shaped spreader or clamp should be used to fasten the splint to the frame or to the lower end of the bed. This prevents both longitudinal and lateral movement of the splint. In practice, however, it is generally found that the splint tends to slide *headwards* down the incline of the bed, so that as a rule it is sufficiently stable if it is tied to the lower end of the bed. If two separate cords are used for this purpose, the splint is steadied also in

regard to lateral movement. When it is desired that the limb should be treated in the abducted position, the splint must be securely fixed at the requisite angle. A firm mattress is essential, and fracture boards should be placed between this and the springs of the bed.

Such splints, however, suffer the general disadvantage of all "fixed" splints (*i.e.* resting on the bed), in that the patient remains anchored in one position in bed; movement at the site of fracture is liable to be caused by any change in position, and by the raising of the pelvis for nursing purposes. In addition, it is frequently difficult in supra-condylar fractures to keep the limb in the correct position in relation to the angle of the splint. An intelligent patient may be able to co-operate in maintaining the position, but even in the most favourable cases constant supervision and adjustment are required.

TREATMENT IN A SUSPENDED PLASTER CAST

A plaster cast may be used with advantage instead of a splint in the treatment of fractured femur. It provides no *true* immobilization; like the splints in general use, it serves mainly to support the limb during the maintenance of traction. Since however an accurate fit can be assured in every case, a relatively greater degree of immobilization can be achieved, and (what is more important) once good position has been obtained, there is no tendency to re-displacement, as there are no slings to work slack. It is essential that traction should be maintained in the line of the femur, and to enable this to be carried out the cast is suspended clear of the bed, so that it has all the advantages of a suspended splint in allowing the patient freedom of movement in bed. In fractures of the lower two-thirds of the shaft, there is no necessity for the plaster cast to include the pelvis, but it is carried as close to the groin as possible, so as to give the maximum of support to the limb. The upper edge of the cast is made fairly thick, and is well smoothed, so as to avoid chafing of the skin.

Methods of application.—It is obvious that the fracture must be reduced by traction before the plaster is applied, and that such traction must be applied with the limb in the position in which it is subsequently to be fixed. It is also necessary that the traction should be evenly maintained during the application of plaster.

It is recognized that the optimum position for immobilizing the limb is one of flexion at both hip and knee joints. The methods of obtaining traction with the limb in this position are illustrated in the accompanying photographs.

In the first method (Fig. 221), a wire or pin is passed through the tibial tuberosity, and traction is applied in the line of the flexed femur, by means of a 20 to 30 lb. weight, while the foot of the bed is raised to provide counter-traction. At the same time, a broad bandage sling is passed below the femur at the site of fracture: this is pulled

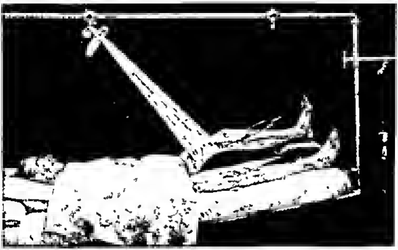


FIGURE 224

Method of applying traction to the femur, prior to the application of plaster. Skeletal traction is obtained by means of a pin passed through the tibial tuberosity. The foot of the bed is raised to provide counter-traction.

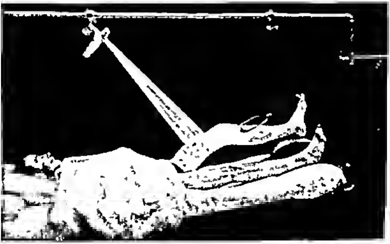


FIGURE 225

Unpadded plaster cast completed from the toes to the groin. A gap is left where the sling emerges, this is closed later. The plaster cast is subsequently suspended and traction maintained by one of the methods shown in Figs. 232 to 234.

upwards and proximally, and is tied to an overhead beam so that it produces an exaggeration of the normal anterior curvature of the femur. Any tendency to backward angulation should therefore be corrected.

If a portable X-ray apparatus is available, it is helpful to have *films taken at this stage and developed at once before the plaster is* applied. Displacement is likely to be spontaneously reduced if the traction is adequate, but if some deformity remains, the fragments can usually be moulded into position.

After reduction is regarded as being satisfactory, the plaster cast is applied. A posterior slab is first laid on, and this is at once converted into a circular cast. The plaster is applied round the pin or wire which is used for the traction: the points of puncture of the skin may be protected with spirit swabs. A gap in the cast must necessarily remain where the sling emerges, as this must be retained in position until setting of the plaster has occurred. The gap may be closed later. The completed cast, which is entirely unpadded, extends from the toes to the groin (Fig. 225).

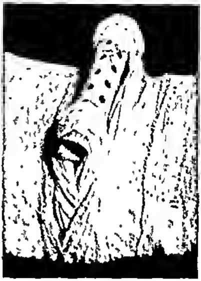


FIGURE 226

A useful method of providing for the suspension of a plaster cast. The cardboard core of a "*Cellona*" plaster bandage is fixed to the anterior surface of the cast in the manner shown.

Provision should be made for the subsequent suspension of the cast. This can be done by utilizing the cardboard cores of "*Cellona*" bandages in the manner shown in Fig. 226. Two cores are incorporated in the front of the cast—one above the ankle, and one above the knee (Figs. 232 and 234). Alternatively simple loops of plaster bandage may be made.

The method described is simple, and by its use most fractures can be brought into good alignment. Occasionally however, in transverse fractures with persistent over-riding, it may be difficult to obtain sufficient traction to correct the displacement. The alternative procedure shown in Figs. 227 and 228 is then to be recommended.

In this method a Kirschner wire is passed through the femur *above the condyles*, and the patient is turned head-to-foot in bed, so that the overhanging arm attached to the head of most hospital beds can be utilized in the manner shown for the application of traction. The end of the bed is raised on chairs, or on very high blocks, and, as the patient slides headwards down the steep slope of the bed, the

FIGURE 227

Alternative method of obtaining traction prior to the application of plaster. This is particularly useful in cases of transverse fracture, where end to-end apposition may otherwise be difficult to obtain. As the patient is pulled down the slope a very considerable amount of traction is produced. An assistant supports the lower leg in moderate flexion

FIGURE 228

Unpadded plaster cast applied to the limb while the traction is maintained. It extends from the toes to the groin and surrounds the Kirschner wire. If possible, reduction should be confirmed by a radiograph, before plaster is applied. The plaster cast is subsequently suspended and traction maintained by one of the methods shown in Figs. 232 to 234.

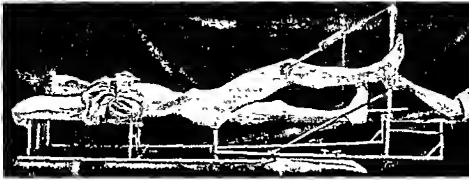


FIGURE 229

Screw traction applied to femur by means of a special appliance which enables this to be carried out with both hip and knee joints in a flexed position. This particular appliance has been designed for attachment to the Author's portable traction table, but some similar form of pulley system could be fitted to any existing orthopaedic table. Sufficient traction is applied to the sound limb to prevent tilting of the pelvis.

leg is suspended and subjected to strong traction. Oblique fractures are immediately reduced. With transverse fractures more difficulty may be encountered, but adequate traction can usually be obtained by

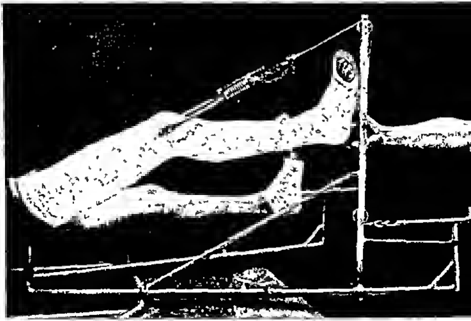


FIGURE 230

Unpadded plaster cast applied while traction is maintained.

(Blocks for Figs. 229 and 230 kindly lent by Medical Supply Association.)

pulling the patient further down the slope. A tensometer spring (Fig. 231) may be used to indicate the amount of traction, and it will be found that 60 to 90 lbs. pull can easily be obtained. (This of

course includes the force of gravity exerted by the limb.) In the great majority of cases such a pull is more than adequate to undo over-riding of the fragments, and as soon as these can be made to grate together the traction is slightly relaxed. An assistant supports the lower leg in moderate flexion, and a plaster cast, extending up to the groin, is applied. For this method of traction it is essential that the wire should be passed through the femur above the condyles: if it is passed through the tibial tuberosity, sagging at the site of fracture will take place.

While the patient is being turned to the normal position in bed, the leg is carefully held by an assistant, who maintains manual traction upon it to prevent re-displacement. Continuous traction is then carried out as shown in Figs. 232 to 234.

Screw traction.—This has been advocated [1] for reduction of the fracture prior to the application of plaster. Special apparatus is required to enable the traction to be applied with both hip and knee

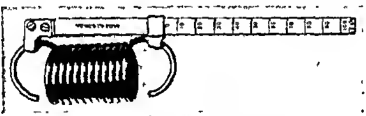


FIGURE 231

Tensometer spring, graduated up to 100 lbs.

(Made for the author by Arch. Young & Sons Ltd.)

joints in the flexed position (Fig. 229). The method has a particular application in the treatment of transverse fractures, where it has not been possible to correct persistent over-riding by the other methods described. A Kirschner wire is passed through the femur above the condyles. The amount of traction employed is gauged by the use of *a tensometer spring (Fig. 231). Portable X-ray facilities are* invaluable in such cases. After reduction has been effected, plaster is applied in the manner already described (Fig. 230).

Maintenance of traction.—It has already been pointed out that the plaster cast provides no *true* immobilization, and if re-displacement is to be prevented continuous traction must be maintained. An adequate weight is attached to the skeletal traction appliance which has been incorporated in the plaster, and a pulley is placed so that such traction is carried out in the line of the femur. The foot of the bed is raised to provide counter-traction, and the cast is suspended clear of the bed so that the lower leg lies horizontal. The different methods of suspension are shown in Figs. 232 to 234.

[1] Farquharson, Eric L., *British Journal of Surgery*, 1938, xxv, p. 592.

Fractures in the upper third of the shaft.—These fractures must be treated with the femur in abduction as well as in flexion. The short plaster cast (including the limb only) may still be used, but it is suspended and traction maintained in the abducted position. Alternatively, the pelvis may be included in the plaster. For the application of such a cast, the screw traction apparatus with flexion-piece should be employed (Fig. 229). This leaves the trunk free for the application of the plaster, while at the same time traction can be carried out.

Where such a hip plaster is used, it is an advantage to maintain continuous traction in the line of the femur, and to suspend the cast

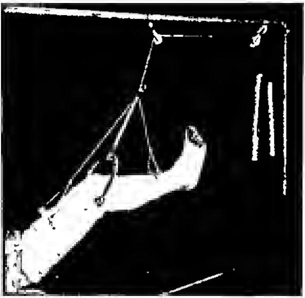


FIGURE 232

Method of obtaining suspension and traction by the use of a single weight. The arrangement of ropes passing through a key ring is well shown. It allows the pull to be equalized at the three points of attachment, whatever the position of the patient in bed The amount of pull varies according to the angle at which traction is maintained. In any case, a considerable weight is required.

so that the lower leg is horizontal (Fig. 235). If this is carried out, the chances of re-displacement are greatly reduced, and pressure from the upper limits of the cast and circulatory disturbance are prevented. In addition, the patient has a very much greater freedom of movement in bed (Fig. 236).

After-treatment.—For the first 24 to 48 hours a careful watch is kept on the colour of the toes, and if there is any suggestion of venous obstruction, the cast is immediately split down the front. If however the plaster has been carefully applied, and continuous traction is maintained, this should never be required. If reduction has been

FIGURE 233

Method by which plaster cast may be suspended and traction maintained. When, as is shown here, traction is applied to the bone above the condyles, one point of suspension is usually adequate.

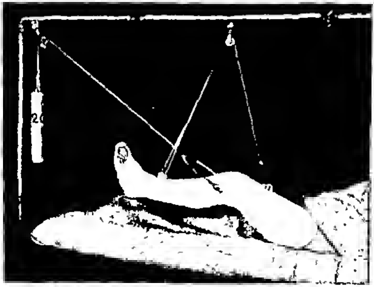


FIGURE 234

When traction is applied to the tuberosity of the tibia, the cast must be suspended at two points. A simple method of suspension is shown, which has been found to be very satisfactory.

FIGURE 235

Fracture of upper third of shaft of femur, treated in a plaster cast in which the limb is immobilized in a position of abduction, slight flexion and slight lateral rotation at the hip joint. Note the method of suspension of the distal part of the cast, and the maintenance of traction in the line of the femur.

FIGURE 236

The same patient as in Fig. 235, photographed while raising himself off the bed. Note the freedom of movement afforded by the method of suspension.

(Figs. 235 and 236 by kind permission of the British Journal of Surgery.)

unsuccessful, the deformity will usually be in the nature of simple angulation, and this can be corrected without difficulty and without the necessity of applying a fresh plaster, by the method shown in Fig. 242.

Traction is maintained for 6 to 8 weeks. After this has been discontinued, the after-treatment follows the general lines laid down on page 177. It is probably simplest to retain the limb in the suspended plaster cast until union is firm.

After four or five weeks, a few patients complain of pain at the back of the heel or at the malleoli, due to pressure from the plaster cast: this is liable to occur even if these bony points have been carefully padded. It should be investigated at once by cutting a window in the plaster over the tender area (Fig. 237).

FIGURE 237

Method of investigating a complaint of pain behind the heel. Two parallel saw cuts are made across the plaster over the plantar surface of the heel. This allows the insertion of shears, with which the cutting is completed. The malleoli may be inspected by raising the plaster edges overlying them.

Advantages claimed for the method.—In all cases, the methods of traction described have been found to give very satisfactory results. The method shown in Figs. 227 and 228 has been particularly effective in the reduction of transverse fractures, where considerable difficulty is often experienced in securing end-to-end apposition. In these fractures, the ordinary methods of continuous traction are frequently found to be unsatisfactory, for, if a weight sufficient to disengage the fragments is left on for more than a very short time, over-distraction is liable to occur.

It has already been suggested that a plaster cast provides much more effective immobilization than any form of splint. As the plaster is applied to the limb, *after reduction has been carried out*, an accurate fit is assured. If such immobilization is combined with continuous traction, re-displacement is very uncommon. The plaster cast, except in cases where it includes the pelvis, is quite unpadded, so that the accurate fit remains constant, and in the great majority of cases, little or no further attention is required. A notable feature has been the comfort which patients have experienced with the leg immobilized in this manner.

A possible criticism of this method of treatment would be that the

prolonged immobilization might lead to troublesome stiffness of the knee joint afterwards, but the extent of flexion (about 20 degrees) in which the joint has been maintained appears to be an adequate safeguard against this complication. Even in cases immobilized for 8 to 10 weeks, painless movement between full extension and 30 to 45 degrees of flexion is frequently possible within a few minutes of the removal of the plaster, and 90 degrees of flexion is usually obtained without difficulty within a week.

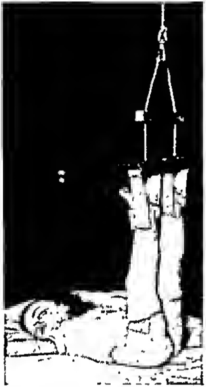


FIGURE 238

"Gallows" traction applied for fractured femur in a young child (*see text*). In this case, a single weight is used for suspending both limbs, which are separated by means of a special spreader (a wooden spar 7 in. long, with a hole at each end). Note the manner in which a pulley is employed to equalize the pull.

FRACTURES OF THE FEMUR IN CHILDREN

In children, a long spiral fracture of the shaft of the femur is a particularly common injury. It usually involves the middle of the shaft, and may extend upwards to just below the lesser trochanter. Transverse fractures are less common; they are usually situated in the upper two-thirds of the shaft. Fractures in the lower third, or supracondylar fractures are rare.

"Gallows" traction.—This is probably the best method of treatment to employ when the child is under five years of age. Owing to the difficulties of nursing, and the delicacy of the patient's skin, methods of treatment advised for the adult are less suitable at this age.

Traction is obtained, through the medium of skin strapping, by suspending the limb vertically at right angles to the body. The greatest care must be taken with the application of the strapping: the two strips must not overlap on the dorsum of the ankle region, and the malleoli should be protected with felt or wool pads. The circular bandage securing the strapping should stop well above the ankle (see also p. 171).

In some cases the fractured leg alone is elevated, but greater comfort is assured and restlessness is better controlled, if both legs are suspended in the same manner. Separate weights may be used for each limb, but the method illustrated (Fig. 238) is simpler, and

FIGURE 239

Manual reduction of a fractured femur in a child. The patient is supported on the pelvic rest of the Portable Traction Table, which provides the counter-pressure.

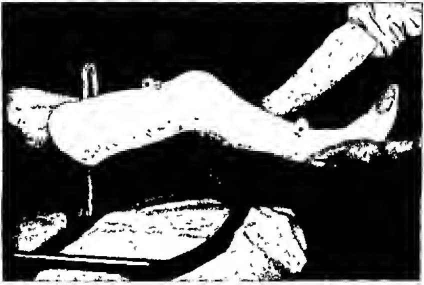


FIGURE 240

Plaster cast applied while traction is maintained. This is padded over the knee and lower leg. Note the cardboard cores bandaged to the front of the cast, *for the purpose of subsequent suspension. A suggestion of backward* angulation at the fracture is apparent; this was subsequently corrected (Fig. 242).

is effective in equalizing the pull. A weight which is just sufficient to raise the buttocks off the bed should be employed.

After-treatment.—Children treated by "gallows" traction usually appear comfortable, and require little attention. The nursing is particularly easy. If restlessness is marked, small co-aptation splints may be applied to the affected thigh, but these are rarely required. Traction is maintained for 4 to 5 weeks. After a further fortnight, during which weight-bearing is prevented, firm union will usually have taken place.

Treatment by a suspended plaster cast.—In older children this method will be found to be very satisfactory. The immobilization

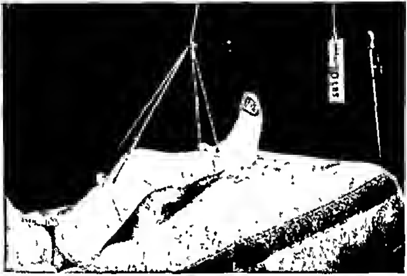


FIGURE 241

Suspension of cast and application of traction on the Hodgen principle. The rope bearing the weight is attached by a slip knot to the two slings (Fig. 215 B), and the angle of pull is varied according to the amount of traction desired. This method, in which traction is applied *directly to the plaster cast*, is probably only suited to the treatment of children. In adults, *skeletal* traction should be maintained in the line of the femur while the cast is suspended (Figs. 232 to 234).

obtained by a well-fitting plaster cast is much more effective than that provided by splints, which, owing to the restlessness of the patient, are always liable to become disarranged.

The fracture should be reduced before the plaster is applied. This is accomplished most easily if the patient is placed on the pelvic rest of an orthopaedic table, when the fragments can be brought into apposition by manual traction (Fig. 239). While traction is maintained by an assistant who holds the knee in a semi-flexed position, the plaster is applied (Fig. 240). The part of the cast surrounding the thigh may be unpadded, but padding around the knee and lower leg is essential. Provision is made for the subsequent suspension of the

cast, by incorporating two cardboard cores on its anterior surface (Fig. 226), or by making simple loops of plaster bandage.

After the patient's return to bed, the cast is suspended and traction applied on the Hodgen principle (Fig. 241). It should be noted that, by this method of treatment, traction is applied *directly to the plaster cast*, so that there is a tendency for the cast to be pulled off the leg, and pressure sores are liable to result where the pull is transmitted to the skin surface of the limb. These can be prevented, however, if two precautions are carefully observed. *The knee must be flexed to an angle of not less than 25 degrees, and the lower leg must be carefully padded, particularly behind the head of the fibula, and over the dorsum of the ankle and foot.* The weight required for the combined traction

FIGURE 242

Correction of backward angulation. (Same case as in Fig. 240.) The cut should extend more posteriorly—otherwise kinking may occur at the back of the cast. Strong traction and counter-traction are maintained during the correction, and while a fresh plaster bandage is being applied.

and suspension will depend upon the size of the child, and the angle at which traction is maintained (p. 184).

After-treatment.—If reduction has been incomplete, the deformity will usually be in the nature of simple angulation. This can be very easily corrected by the method shown in Fig. 242. The cast is sawn through at the site of fracture around three-quarters of its circumference, and the angulation is corrected while traction is maintained. The skin under the cut edges of the cast is protected by strips of lint, and a further plaster bandage is applied to consolidate the cast in the corrected position. After satisfactory alignment has been obtained, little further attention is required, but any signs of pressure from the cast must be immediately investigated. After three to four weeks, when sufficient callus will have formed to prevent re-displacement, the traction may be gradually reduced, by arranging the cords so that the weight serves mainly to procure suspension of the limb. Union should be completely firm in six to eight weeks.

XVII

THE KNEE JOINT

MANIPULATIVE TREATMENT

MANIPULATION has been very widely employed in the treatment of injuries of the knee joint, and has been responsible for many complete and lasting cures of chronic disability. Illustrations of the different methods employed, and a short account of the indications for their use, are therefore worthy of consideration here. There are two main conditions which call for this form of treatment. The first is chronic stiffness of the knee, which may follow upon inflammatory conditions or trauma affecting the joint, or upon fractures in the vicinity. The second is instability of the knee joint with recurrent attacks of pain and locking, which are dependent upon the existence of a torn or displaced semi-lunar cartilage.

Stiff knee.—Stiffness of the knee joint following inflammation or trauma is due to the development of adhesions. *Intra-articular adhesions* form between neighbouring folds of synovial membrane or between the articular surfaces; they are caused by the organization of exudate. *Peri-articular adhesions* are most common after fractures in the vicinity of the joint, when immobilization may have been carried out for long periods. They affect the capsule and the peri-articular tendons and muscles, in which shortening and loss of elasticity may also occur. Intra- and peri-articular adhesions are frequently combined. The former are caused by a primary joint condition, while the latter usually result from the immobilization which forms part of the treatment.

Sprains of the collateral ligaments frequently give rise to adhesions, which are the aftermath of the traumatic synovitis produced at the time of injury. Such adhesions occur chiefly between the two layers of synovial membrane, as this is reflected from the deep surface of the ligament on to the femoral condyle.

Fractures of the femur and tibia involving the joint are another very frequent cause of adhesions. Effusion of blood into the joint may mingle with synovial exudate to produce a haemarthrosis. Adhesions which result from organization of blood clot tend to be more generalized and to be most marked in the front and lower part of the joint, and in the region of the infra-patellar pad of fat and its processes (Timbrell Fisher).

Both intra- and peri-articular adhesions may often be prevented in the immediate treatment of the primary condition, by early movement or by the employment of quadriceps exercises, but once they

have developed, forcible manipulation offers the best and possibly the only prospect of cure. The best results are of course obtained when the adhesions are slender and require little force for their disruption, and where they are not associated with changes in the articular surfaces. The employment of excessive force is always to be deprecated, as it may lead to injury to bones or muscles. This risk is of especial significance in manipulating a knee for stiffness following fractured femur. Strong adhesions are frequently present between the quadriceps tendon and the anterior surface of the femur, and too forcible manipulation may result in fracture of the patella, or in disruption of its tendinous attachments.

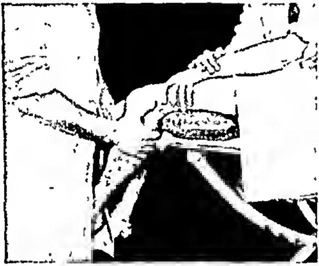


FIGURE 243

Method of manipulating knee joint. Note how the bending is performed by movements of the surgeon's thighs, *between which the patient's foot is held*; the surgeon then has his hands free to control the head of the tibia. An assistant protects the femur by firm pressure over a sandbag.

In cases where dense vascular adhesions are present, the results of manipulation are less satisfactory. The severe reaction which follows the rupture of such adhesions, together with the possible production of a haemarthrosis, may result in the formation of new adhesions, and in further limitation of movement.

Cases of chronic arthritis are sometimes treated successfully by manipulation, but there is a great tendency, especially in older patients, for adhesions to re-form, and the results are apt to be disappointing. In the case of adhesions due to an old tuberculous infection, manipulation is definitely contra-indicated.

Technique of manipulation.—An anaesthetic is required in order that full muscular relaxation may be obtained. Timbrell Fisher gives the following description of the method of manipulation. The patella

and infra-patellar pad of fat should first be mobilized as much as possible. The surgeon's thumbs are placed on either side of the patella, and the bone is pushed firmly from side to side. The process is repeated over the infra-patellar pad of fat. For the main part of the manipulation, the patient lies with the affected leg bent over the end of the table. The surgeon seats himself or stands if necessary in such a way that the patient's foot is firmly fixed between his thighs, while with both hands he grasps the patient's knee, which he thus steadies and supports. The actual bending of the patient's limb at the knee is performed by the movements of the surgeon's thighs, assisted by his hands which also control and support the knee joint (Fig. 243). Another advantage of this grip is that very powerful

FIGURE 244

Manipulation to obtain full flexion.

FIGURE 245

Manipulation to obtain full extension.

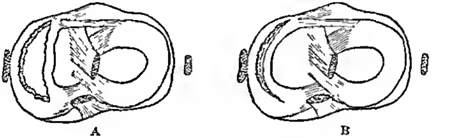
rotation can be performed if necessary, by a lateral inclination of the surgeon's thighs, combined with a firm rotatory movement in the same direction of the tibia, the head of which is firmly grasped by the surgeon's hands. In addition, an attempt may be made to elicit some "fore-and-aft" movement of the head of the tibia on the femur.

Where movement is limited only at the extremities of the normal range, more vigorous manipulation may be carried out. Using the long leverage of the lower leg, the surgeon may flex the knee by a series of short sharp jerks until the back of the leg touches the buttock (Fig. 244). Full extension may be obtained by the manipulation in which the surgeon places the patient's heel on his shoulder (Fig. 245), and, clasping his hands over the knee, pulls it downward into full extension.

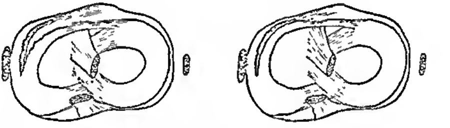
After-treatment.—Particular attention is paid to maintenance of

the increased range of movement obtained by the manipulation. The patient should be allowed to recover from the anaesthetic with the knee in the flexed position, so that he himself may see the range of movement which is now possible. In milder cases, and where little or no reaction has resulted from the manipulation, active use of the limb should be undertaken immediately, but if much pain and swelling are present, a few days' rest will be necessary. In such cases, the limb should be placed on an inclined plane so that the degree of flexion may be maintained. Quadriceps exercises should be practised assiduously, until active use of the limb is recommenced.

Injuries of the medial semi-lunar cartilage.—The injuries most commonly found are tears of the "bucket-handle" type which involve



"Bucket-handle" tear of medial semi-lunar cartilage.



Longitudinal tear of anterior horn of cartilage.

FIGURES 246 AND 247

A.—The displacement typically produced in each type of injury.
B.—*Reduction of the displacement, which manipulation is designed to achieve.* Note how the outer rim of the cartilage is fixed by its attachment to the medial collateral ligament.

the greater part of the cartilage, and tears of the anterior horn alone. In either case the characteristic complaint of locking of the joint is due to displacement of the torn fragment towards the centre of the joint, so that it is nipped between the weight-bearing parts of the articular surfaces, and full extension becomes impossible.

Manipulation is called for in the acute stage when the joint is actually locked, but it may also be helpful in the treatment of the more chronic condition which is characterized by periodic attacks of locking, together with the complaint of instability of the joint. In the common "bucket-handle" type of tear, between the attacks of

locking, the torn segment of cartilage is frequently displaced further laterally towards the inter-condylar space, where it escapes pressure from the femoral condyle in full extension. Locking then occurs only at irregular intervals, when, as the result of some rotational strain, the torn segment becomes displaced *medially* below the condyle.

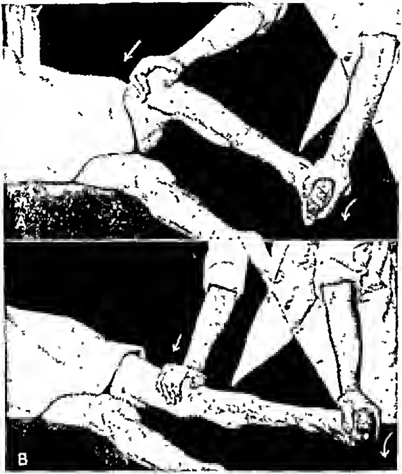


FIGURE 248

Method of reduction of a displaced medial semi-lunar cartilage. The knee is sharply extended, while, at the same time, the medial side of the joint is opened up, and the lower leg is rotated medially.

Manipulation is designed to replace the torn segment of cartilage, which has been dislocated towards the interior of the joint. In recent cases the reduction is usually successful, as the manipulation is assisted by the elastic tendency of the displaced portion to spring back into position, but in chronic cases, and particularly in tears of the "bucket-handle" type where the torn segment lies in the inter-condylar space, reduction may be difficult or impossible. Complete muscular relaxation is usually essential, but a preliminary

attempt at reduction may be made without an anaesthetic, as the patient can assist in the final stages of the manoeuvre by kicking his leg into full extension.

Technique of manipulation.—The knee is first fully flexed, and while in this position it is abducted as much as possible in order to open up the inner side of the joint. Rapid movements of rotation are then carried out. Excessive medial rotation of the lower leg is then obtained by twisting the foot inwards, while the medial side of the joint is kept open by the pressure of the surgeon's hand on the lateral side of the knee (Fig. 248 A). While the abduction and medial rotation are maintained, the knee is forcibly extended (Fig. 248 B), when the cartilage may slip back into position with an audible click. If the patient is un-anaesthetized and is co-operative, he may assist the surgeon by voluntarily kicking the leg into full extension. If actual

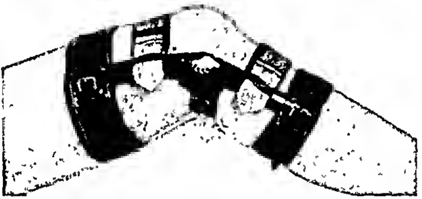


FIGURE 249
Knee cage.

locking was present before the manipulation, it will be at once apparent if success has been achieved, as the patient should now be able to extend the knee fully without pain.

After-treatment.—The post-reduction treatment of an *initial* cartilage injury consists of complete immobilization of the knee joint for four weeks, in the hope that the tear may be situated in the vascular peripheral part of the cartilage, where there is at least some prospect that healing will occur. During this time quadriceps exercises are essential if wasting is to be avoided.

In recurrent dislocation healing is impossible, and prolonged immobilization leads only to adhesions and muscular wasting. Operative removal of the cartilage should usually be undertaken. In older patients and in those whose activities are not greatly affected, operation may be contra-indicated or may be declined. In such cases re-displacement can often be prevented by the wearing of a knee cage (Fig. 249), which permits of full flexion and extension at the joint, but gives lateral support and prevents twisting strains.

XVIII

FRACTURES OF THE LOWER LEG

FRACTURES of the tibia and fibula may occur at any level, depending on the nature and direction of the fracturing force. Accurate reduction is of particular importance in these fractures. The lower leg is bounded above and below by joints which have mainly a hinge-like action, and in which the axis of movement is normally parallel. Any deviation from the normal alignment destroys this relationship, and may have far-reaching effects on the joint functions.

In some cases, the joints are more directly affected, as if the fracture is high up it may extend into the knee joint, and if it is low down, the ankle joint may be involved. Treatment must be directed as far as possible to restore the normal architecture of the joint. Fractures which involve the ankle joint are considered in the next chapter, p. 228.

FRACTURES OF THE UPPER END OF THE TIBIA

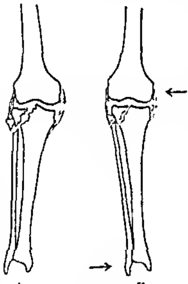


FIGURE 250

Fracture of lateral condyle of tibia and head of fibula, with rupture of medial ligament. Note displacement (*A*), and method of correction (B).

Fracture of the lateral condyle.—This fracture is usually caused by a blow on the lateral side of the knee, as may result from the impact of a motor car bumper or from the falling of a heavy weight. The joint is forced into valgus deformity, with the result that the medial collateral ligament is torn, and the lateral condyle of the tibia is fractured from direct contact with the femoral condyle. The fractured part of the condyle is either depressed and impacted in the cancellous bone of the upper end of the tibia, or it is displaced and tilted to the lateral side. Frequently the upper end of the fibula is also fractured. Genu valgum deformity is apparent, and there is abnormal lateral mobility.

Treatment.—Considerable swelling is usually present, and there may be an effusion of blood into the knee joint. This should be treated by aspiration. It is usually possible to reduce the main displacement by forcible over-correction of the genu valgum deformity, as the

fractured condyle is then pulled upwards into its normal position by the strong collateral ligament (Fig. 250). Lateral displacement is corrected by compression between the surgeon's hands, or by the use of a rubber bandage or special clamp applied to the condyles (Fig. 253). The knee is fixed *in full extension* by a plaster cast, extending from the upper third of the thigh to just above the ankle. While setting is occurring, the adducted position is strongly maintained (Fig. 251). The cast should be well padded around the knee, or pressure sores are liable to result.

FIGURE 251

Application of plaster cast for fracture of lateral condyle of tibia. Note how the valgus deformity is corrected by pressure maintained during setting of the cast (see also Fig. 250).

If satisfactory reduction is not obtained by this manipulation, open operation should be considered. The fractured condyle is pressed into position under direct vision, and is secured by a beef bone peg (Plate XXVIII) or by an autogenous bone graft.

After-treatment.—After the initial swelling has subsided, the plaster cast will be found to be too loose fitting for satisfactory immobilization. It should therefore be renewed after three weeks. The second cast may be unpadded, except for a broad pad of felt over the medial side of the knee joint, where pressure is maintained as before during setting (Fig. 251), and a narrow felt ring, which protects the skin from the lower edge of the cast.

The patient may be allowed to bear weight on the limb after the application of the second plaster cast, provided that this is tight-fitting. Fixation must be continued for 10 to 12 weeks, as, if *unsupported* weight-bearing is allowed before union is completely firm, an unstable knee joint with valgus deformity may result.

Fractures of both condyles.—The fracture, which is the result of a more severe injury, is usually T- or Y-shaped. The two condylar fragments are often widely separated, and the upper end of the shaft is driven upwards between them towards the joint (Fig. 232). Considerable swelling and effusion are always present, and it is sometimes advised that reduction should be postponed until this has partially

subsided. As in the case of fractures elsewhere, however, swelling is likely to persist to a great extent as long as the deformity remains uncorrected, and, in addition, there is the risk of the vessels and nerves of the popliteal region being stretched by the displacement of the fragments. It is most essential therefore that reduction should not be delayed.

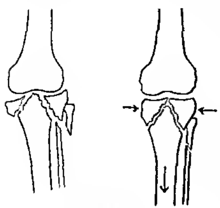


FIGURE 252

Inter-condylar fracture of tibia, with typical displacement. Note how the two condylar fragments are separated by the lower fragment being driven up between them. Reduction is effected by strong traction, followed by side-to side compression of the condylar fragments.

Treatment.—The first step in reduction of the deformity must be the application of strong traction to the lower fragment. When this has been pulled out from between the condylar fragments, these can be pressed into apposition. Böhler's screw traction appliance is most effective in providing the necessary traction. 40 to 60 lbs. traction is applied to a pin or wire passed through the calcaneum. Various compression clamps have been used for obtaining apposition of the condylar fragments (Plate XXXIII), but the method illustrated in Fig. 253 (Kindersley) is simpler, and has been found to be very satisfactory in use. *Portable X-ray facilities are of course invaluable.*

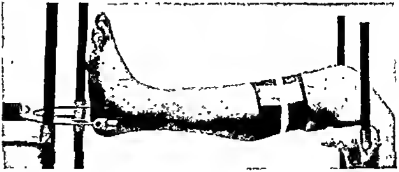


FIGURE 253

Inter-condylar fracture of tibia. The lower fragment is pulled down by strong traction, in Böhler's screw traction apparatus, and the condylar fragments are pressed together by a rubber bandage applied very tightly round the limb over the *lower* part of the condyles. The bandage is retained for 2 or 3 minutes. *(I am indebted to Mr. Charles Kindersley for this suggestion.)*

After reduction has been effected, the traction is relaxed to 15 lbs., and a plaster cast is applied to prevent re-displacement. Thereafter, traction should be continued on a Böhler's lower leg splint

(Figs. 254 and 256). It is advisable that the cast should be split down the front (Fig. 263), as after screw traction there is always a danger of circulatory interference.

If a screw traction appliance is not available, continuous traction may be carried out from the first, but a considerable weight (15 to 20 lbs.) will be required to pull down the lower fragment, and the foot of the bed must be correspondingly raised.

After-treatment.—Continuous traction is carried out for 6 to 8 weeks, after which the position is maintained by a plaster cast which extends up to the groin, and includes the foot. Weight-bearing is not allowed until there is radiological evidence of consolidation. A "walking" plaster cast, extending up to the groin, should be worn for several weeks after the commencement of weight-bearing, as there is a tendency for valgus or varus deformity to develop.

FRACTURES OF THE SHAFTS OF TIBIA AND FIBULA

These fractures vary in type with the nature and direction of the fracturing force. Transverse fractures are usually the result of direct violence, and may occur in any part of the bones. If the tibia or fibula alone is fractured, displacement is usually slight or absent, as the sound bone acts as a splint for the broken one. More commonly, however, the fracture is due to some form of indirect violence such as tortional strain, when an oblique or spiral fracture involving both bones is most likely to occur. Very frequently the tibia is fractured in its lower third, and the fibula in its upper third, each bone giving way at its weakest part.

Reduction can often be effected without difficulty by manual traction alone, but in many cases, and particularly in oblique fractures, it may be difficult to maintain the position, and the application of continuous traction is then advisable.

Technique of continuous traction on the lower leg.—For the application of continuous traction to the lower leg, there is probably no appliance which can equal Böhler's lower leg splint for effectiveness and simplicity. This splint (see also Plate XXXII) supports the limb with the knee in a flexed position, and the elevation of the lower leg improves the circulation and reduces swelling. A pulley is provided for traction in the line of the bones. The standard size of splint will fit any adult case, and it is the work of a few moments to arrange the bandage which is to support the limb (Fig. 254). Skin traction is rarely satisfactory, as, in the presence of swelling, blistering is very liable to be produced. Skeletal traction is usually employed; this is obtained by a pin or wire passed through the calcaneum, the bone being transfixed at a point 1" below and behind the lateral malleolus. A weight of 6 to 12 lbs. is attached, depending on the amount of displacement present, and on the muscularity of the individual. The

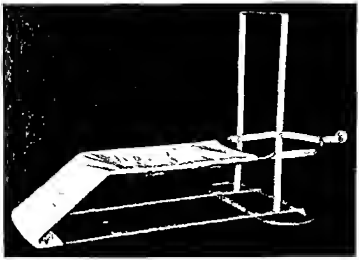


FIGURE 254

Böhler's lower leg splint, bandaged ready for use. Note how the bandage is carried round the proximal angle of the splint, and that it is passed *slackly* between the horizontal bars to allow for the expansion of the calf.

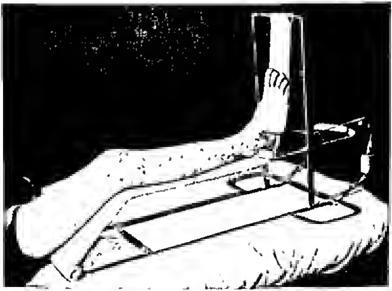


FIGURE 255

Continuous traction in the lower leg splint. Skeletal traction is obtained by a Kirschner wire passed through the calcaneum, and 6 to 12 lbs. weight is attached. The foot is suspended by strapping. The splint is tied to the foot of the bed, which is elevated.

foot of the bed is raised to provide counter-traction. It is necessary to tie the splint to the foot of the bed to prevent it from sliding headwards. Foot-drop is largely prevented by the calcanean traction, but it is an additional advantage to sling the foot by means of adhesive strapping to the upright hoop of the splint. This serves also to prevent rotation of the lower leg, and reduces the pressure of the heel or tendo calcanei on the supporting sling (Fig. 255).

In the majority of cases of oblique fracture, the deformity will be reduced, and satisfactory position of the fragments maintained, if continuous traction is applied in the manner described, but in other

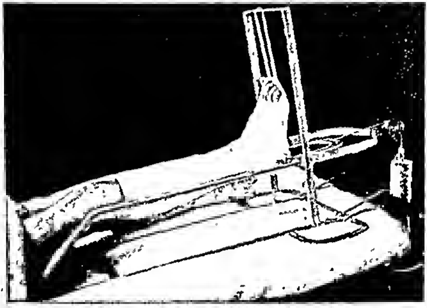


Figure 256

Continuous traction, combined with plaster fixation. The leg is effectively steadied, and rotation prevented, if the foot is suspended as shown, by a piece of tape, passed through a hole bored in the toe-piece of the cast.

cases it will be necessary for the traction to be combined with plaster fixation (Fig. 256).

Böhler's lower leg splint in wood.—The original pattern of Böhler's splint (made up in iron) is heavy (11 lbs.), cumbersome and difficult of storage. To obviate these objections, and to meet the war-time shortage of iron, a wooden splint designed on similar lines has been described.[1] Hardwood spars, seven-eighths of an inch square on cross-section, are used throughout. The essential features of the metal splint have been copied, but, for simplicity and ease of storage, the broad base has been dispensed with—the splint is quite steady without it; so also has the upright hoop which keeps the bedclothes off the foot, an ordinary cage being used instead for this purpose.

[1] Farquharson, Eric L., *British Medical Journal*, 1940, vol. i, p. 350.

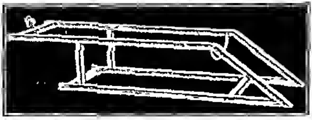


FIGURE 257
Böhler's lower leg splint made in wood.

FIGURE 258
The splint bandaged ready for use.

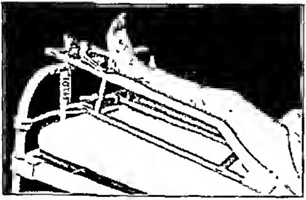


FIGURE 259
The splint in use for the application of continuous traction.

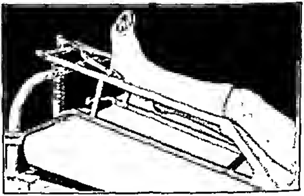


FIGURE 260
Continuous traction combined with plaster fixation.

(Figs. 257 to 260 by courtesy of the British Medical Journal.)

A metal spreader is placed between the spars at the angle of the splint; it prevents these from becoming approximated by the tension of the bandage, and ensures complete rigidity; being curved, it lies well clear of the leg.

The wooden splint has been given an extensive trial and has been found to be entirely satisfactory. Its use is shown in the accompanying photographs (Figs. 257 to 260). It weighs only 3 lbs., and takes up little room on storage.

Screw traction.—This method of reducing lower leg fractures has been popularized by Böhler. The appliance used for the purpose is illustrated in Plate XXXIII, where a detailed description of its con-

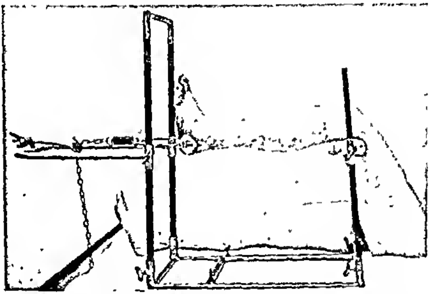


FIGURE 261

Böhler's screw traction apparatus in use. *(See description to Plate XXXIII.)* A Kirschner wire is passed through the calcaneum. The use of a traction indicator (Fig. 231) is essential. Note how the leg is left entirely free for the *application of plaster.*

struction is available. A pin or wire is passed through the calcaneum, and the knee is flexed over the transverse bar, so that the gastrocnemius is fully relaxed. The shape of the transverse bar provides for the more distal insertion of the hamstring tendons on the medial side, so it must be adjusted to suit right- or left-sided fractures. A tensometer spring (Fig. 231) is placed between the skeletal traction appliance and the hook on the screw; the intermediate connection is conveniently made with a piece of chain, which does not give in the way that rope does, and is more easily adjusted. Traction is obtained by turning the wing nut which is threaded on the screw. The amount of traction required varies with the individual case. Oblique fractures are easily reduced by 15 to 20 lbs. traction, but

transverse fractures may require a pull of 50 lbs. or more, before the fragments can be disengaged, and end-to-end apposition obtained. While traction is being applied, an attempt is made to press the fragments into position. The assistance of a portable X-ray apparatus is invaluable, especially if there are facilities for the immediate development of films.

After reduction has been effected, a plaster cast is applied. One

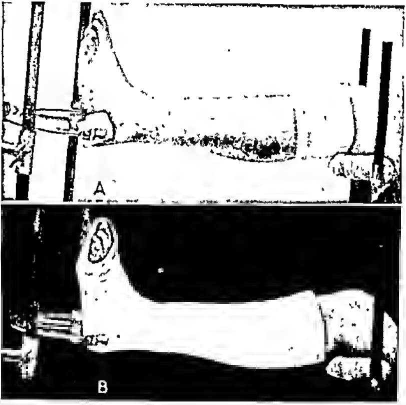


FIGURE 262

Plaster fixation of a lower leg fracture after reduction by screw traction. *The traction must be relaxed to 15 lbs. before plaster is applied.* The plaster cast is unpadded, except for a ring of felt and/or lint at its upper edge, but it is a wise precaution to split the cast down the front, before the patient returns to bed. (Figs. 263 and 264.)

of the greatest advantages of the screw traction appliance (apart from the provision of screw traction) is that it leaves the leg entirely free for the application of plaster, and that it maintains traction evenly while this is being done. Except for a ring of felt or lint below the knee, the plaster cast is unpadded. A plaster splint is first applied: this extends from below the knee to the tip of the toes and is carefully moulded to the posterior surface of the leg and sole of the foot. This is now converted into a circular cast, which fits closely around the

pin or wire transfixing the calcaneum. *Spirit swabs may be used to protect the points of puncture of the skin (Fig. 262 A).* While the

FIGURE 263

Method of splitting a plaster cast while it is still wet. The skin is protected by a strip of felt which is shown.

plaster is drying, even pressure is made over the medial side of the leg, *so that the normal bowing of the bones may be preserved.*

The method of screw traction is not without danger.—This danger lies not in the amount of traction employed, provided that it is of

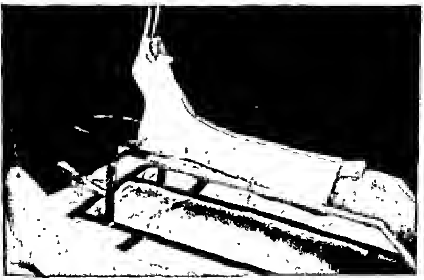


FIGURE 264

Continuous traction maintained in a *split* plaster cast. This precaution is especially advised after reduction by screw traction.

short duration, but in the amount of traction maintained during the application of plaster. As much as 200 lbs. traction has been applied without ill-effect in the case of old-standing transverse frac...

with obstinate displacement; the occlusion of the popliteal vessels is only temporary, and the ligaments of the knee joint do not appear to suffer. *It should be made a rule, however, that, during the application of the plaster, the traction should be relaxed to not more than 15 lbs.* The necessity of one other precaution must be stressed. *If swelling of the limb is present at the commencement of treatment, the cast must be split down the front.* (The surgeon will enjoy more peace of mind if this is done in *all* cases.) A very simple method of splitting the cast is shown in Fig. 263. A strip of felt or rolled-up lint is laid along the anterior surface of the leg and foot before the plaster is applied, and the cast, while it is still wet, is easily cut through in this line. The felt not only protects the skin from the knife, but it also prevents irritation from the cut edges of the cast, or oedematous bulging through the split. A split cast of this type fits closely, but will give considerably in the presence of swelling. Alternatively, it can easily be prized open by a nurse.

After the patient's return to bed, continuous traction should be maintained in the lower leg splint (Fig. 264). This not only prevents re-displacement, but minimizes the chances of circulatory obstruction. The nurse should be impressed with the possibility of this danger, and instructed to keep a careful watch on the colour of the toes. At the first suggestion of venous stasis the cast should be split. If this has already been done, the split should be widened. As Böhler has remarked, there is nothing so frightful as the loss of a leg, due to a plaster cast which has been applied too tightly.

Plaster fixation.—As fractures of the shafts of the lower leg bones are usually attended by considerable swelling, the application of a plaster cast in the early stages of treatment has certain disadvantages. As swelling subsides, the immobilization may soon be found to be inadequate, and a second plaster cast will usually need to be applied. Alternatively, there is the danger that further swelling within a rigid cast will cause circulatory interference. In the case of oblique fractures, where displacement has been reduced, a plaster cast which satisfies the requirements of safety in being loose fitting may be inadequate to prevent a recurrence of the deformity, and it should therefore be combined with continuous traction (Figs. 256, 260 and 264). In many cases it is possible to maintain position by continuous traction alone, or by means of a dorsal plaster splint (Fig. 265), and it then simplifies treatment, if the complete cast is applied only after all swelling has subsided.

"*Walking*" *plasters.*—The walking plaster cast is fully dealt with in the section on Pott's fracture (p. 231). The advantages of this form of treatment are equally applicable to fractures of the shafts of tibia and fibula, but except in cases of fracture of one bone alone, or in transverse fractures with little or no swelling, the method cannot be employed in the initial stages of treatment.

The first essential of a walking plaster is that it should be tight fitting, and a plaster cast applied in the early treatment of lower leg fractures will not remain tight fitting—either because swelling has

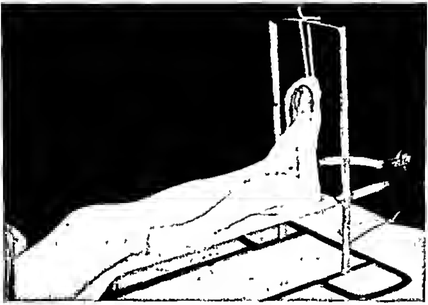


FIGURE 265

Temporary method of treatment in lower leg fractures, where considerable swelling is present, but where there is insufficient displacement to warrant continuous traction.

subsided, or because of wasting of the limb in the absence of muscular activity (see also p. 234). The walking plaster (*i.e.* the plaster cast in which the iron stirrup is to be incorporated) should only be applied therefore *when swelling has subsided, and when the patient is ready*

FIGURE 266

Temporary plaster cast for lower leg fracture. It is unpadded but is split over a strip of felt (Fig. 263). With such a plaster, the patient may be discharged on crutches, until such time as a "walking" plaster can be applied.

for weight-bearing. Until these conditions are satisfied, continuous traction may be maintained, or the patient may be discharged home in a temporary plaster (Fig. 266), with instructions to use crutches and to bear no weight on the limb.

The walking plaster cast for a fracture of both bones should extend up to the middle of the thigh (Fig. 267). *The knee is maintained in about* 10 *degrees of flexion.* This not only minimizes stiffness afterwards, but prevents any possibility of rotation at the fracture site. The heel on the sound side should be raised, to compensate for the functional inequality in the length of the two limbs.

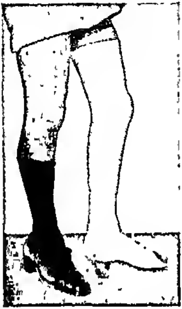


FIGURE 267

"Walking" plaster for lower leg fracture. Note the degree of flexion at the knee, and that the *heel on the sound side is raised.*

The duration of immobilization required varies within wide limits according to the type and situation of the fracture. A fracture of one bone alone may be completely firm in 6 weeks or less. For fractures of both bones, 8 to 12 weeks may be suggested as the average time required. In such cases, a full-length plaster cast should be worn until the fracture is judged on radiological evidence to be firmly united. The cast may then be cut round at the level of the tibial tuberosity, and the upper part removed. The short cast which remains gives support to the healed fracture, and imparts a sense of confidence to the patient in his suddenly acquired freedom of movement at the knee joint. It is removed in three to four weeks' time. If the cast is not tight-fitting around the lower leg, it is better to discard it altogether or to apply a new cast extending up to knee level.

Delayed union and non-union.—In general, transverse fractures heal more slowly than oblique fractures, and fractures of both bones in the middle third are notorious for delayed union. If union is found to be incomplete, the walking plaster is immediately renewed; this should extend up to mid-thigh level, so that the immobilization provided may be above reproach. Three or four successive plasters may be necessary over a period of six to nine months. Stiffness of the ankle joint or wasting of the limb will not occur, provided that muscular activity is maintained (p. 234). In obstinate cases, multiple drilling of the fragments or a bone-grafting operation may be carried out.

Treatment applied to different types of fracture.—The treatment suggested for the different fractures of the shafts of tibia and fibula may be summarized as follows.

(1) *Fractures of one bone alone, or fractures without displacement.* —In the absence of swelling, an unpadded plaster cast may be im-

mediately applied. A dorsal plaster slab is first laid on; this is converted into a circular cast, and later, by the incorporation of an iron stirrup, into a walking plaster (Fig. 267). In cases where swelling is present, a *temporary* plaster cast only is applied. If the patient is to be kept in hospital, the leg is then elevated on the lower leg splint (Fig. 265). Alternatively, he may be discharged home on crutches. The walking plaster is not applied till all swelling has subsided.

(2) *Spiral or oblique fractures involving both bones* are best treated by continuous traction, with or without plaster fixation (Figs. 255, 256, and 264). It is unsafe to allow weight-bearing till 4 or 5 weeks have elapsed, as, even in the most closely fitting plaster, displacement is liable to recur. Continuous traction may be maintained for this period, or the patient may be discharged in a *temporary* plaster (Fig. 266), before returning for the walking plaster to be applied.

(3) *Transverse fractures.*—Screw traction is a valuable aid to accurate reduction (Fig. 261). It should be followed by continuous traction, used in conjunction with a *split* plaster cast (Figs. 263 and 264). A walking plaster is applied as soon as swelling has subsided. In the middle third of the tibia union is slow, and the period of immobilization required may extend into several months.

(4) *Compound fractures.*—Owing to the subcutaneous situation of the tibia, compound fractures of the lower leg are particularly common. The most important part of the treatment may be said to be the surgical toilet of the wound of the soft tissues. A detailed description of the procedures advised is outwith the scope of this book, but an attempt is made to remove all damaged and contaminated tissues, including the skin edges, portions of subcutaneous tissue and muscle, and loose bone fragments. The depths of the wound may be irrigated with saline solution, but strong antiseptics should not be applied.

If the injury is less than 8 hours old, and the destruction of tissue is not extensive, the wound may be completely closed in an attempt to convert the injury at once into a simple fracture. The skin alone is sutured and buried ligatures should be avoided except where they are necessary for the occlusion of larger vessels. *It is essential that there should be no tension on the skin flaps.* These should be approximated only where this is possible without tension; the remainder of the wound is lightly packed with gauze, or a sheet rubber drain is inserted.

If treatment is begun more than 8 hours after the injury, or if there is extensive destruction of soft tissue, débridement should be carried out as in the case of more recent injuries, but it is unwise to attempt any suture of the wound; this should be left wide open and packed with gauze.

Further treatment follows the lines laid down for simple fractures. Continuous traction in the lower leg splint (Fig. 255) will usually serve to maintain position, but preliminary screw traction (Fig. 261) may

be required for the reduction of transverse fractures with displacement. If the skin wound has been closed by suture, it is better to avoid plaster fixation in the early stages of treatment, unless the

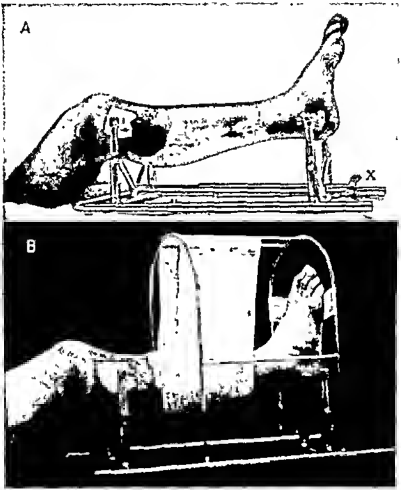


FIGURE 268

Compound fracture of lower leg bones (wound on medial side), treated in special traction apparatus. This consists of two tubular steel frames which telescope into one another. Each frame has a pair of uprights adjustable in height, between which a Kirschner wire can be stretched and clamped. The wires are passed through the tibial tubercle and calcaneum, and the leg is suspended between these two points, so that all surfaces are accessible for dressing. Distraction is obtained by turning the screw (X). A wire cage fits into sockets on the frame, and to this, a sling is attached to prevent sagging of the leg in the middle.

(Made for the author by J. Gardner & Son.)

position of the fragments cannot otherwise be maintained. The wound heals best when exposed to the open air, as any discharged serum dries rapidly, and the skin does not become macerated from

contact with sodden dressings. In addition, the wound can be kept under continual observation. This is very essential, in order that the stitches may be removed at the first sign of septic infection. A plaster slab is preferable to a circular cast, as it can be applied to leave one surface of the leg entirely uncovered. The cutting of a window in a circular cast is not very satisfactory, as it allows oedematous bulging of the tissues, and healing is delayed. It is unwise to consider the use of a walking plaster until the wound has completely healed, and all swelling has subsided.

In cases which are left with a large wound of the soft tissues, with or without septic infection, the Winnet Orr treatment has given excellent results. In this, the wound is packed with vaselined gauze, *and the limb is enclosed in a complete plaster cast without windows.* Progressive healing will usually occur with this treatment. In septic cases, the necessity of renewing the dressing and plaster will be determined by the offensiveness of the discharge.

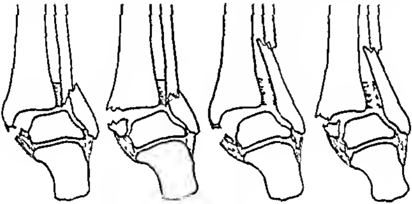
In compound fractures with extensive injury to the soft parts, the special traction appliance shown in Fig. 268 has proved useful. The lower leg is suspended between two wires passed through the tibial tubercle and calcaneum, and is entirely accessible for dressings. The two pairs of uprights which carry the wires can be moved apart by the action of a single screw, so that distraction is readily obtained.

XIX

INJURIES TO THE ANKLE JOINT

FRACTURES OF THE MALLEOLI (POTT'S FRACTURE)

THE clinical term "Pott's fracture" is used to refer to various fractures in the region of the ankle joint, which, although varying in their anatomy, are all the result of injuries causing abduction or lateral rotation of the foot. They are produced by falls on the everted foot, or by rotational strain where the leg is rotated medially on the fixed foot. The essential feature is a fracture of the fibula towards its lower end. This fracture is produced, either by outward pressure of the talus on the fibula, or by rotational strain



A B C D

Figure 269

Different types of "Pott's fracture" with lateral dislocation.

A.—Fracture of lateral malleolus with rupture of medial ligament.
B.—Fracture of lateral malleolus with avulsion of medial malleolus.
C.—Fracture of fibula above ankle joint, *with rupture of medial ligament.*
D.—Fracture of fibula above ankle joint, with avulsion of medial malleolus.
(C and D) Lateral dislocation can only occur if the interosseous tibio-fibular ligament is torn.

alone. In the former case, the fracture is likely to occur at the malleolus (Fig. 269 A and B); in the latter, it is more often situated two or three fingerbreadths above the joint (Fig. 269 C and D).

The typical Pott's fracture is associated with a varying degree of lateral dislocation of the talus and foot as a whole, although this may have undergone spontaneous reduction, and will not be apparent at the time of examination. For such dislocation to occur, one of two injuries must be present at the medial side of the joint—either the medial ligament may be ruptured (Fig. 269 A and C), or, if this is

sufficiently strong to stand the strain, the malleolus may be torn off near its base and displaced laterally with the talus (Fig. 269 B and D). In cases where the fibula is fractured above the malleolus, lateral dislocation can only occur, if, in addition to the other injuries described, there is a complete rupture of the interosseous tibio-fibular ligament (*Figs.* 269 *C and D*).

Posterior dislocation is also a common complication, and is most likely to be produced if the abduction strain falls upon the foot in the plantar-flexed position. In such cases a fragment is broken from the posterior margin of the tibia, carrying with it one-third or less of the articular surface. If the line of fracture is oblique, the medial malleolus may be included. This fragment together with the foot as a whole is displaced backwards and upwards, and the anterior liga-

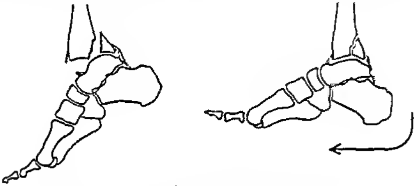


FIGURE 270

Pott's fracture with posterior dislocation.

Note how the fracture involves the posterior part of the articular surface of the tibia. The fragment together with the foot as a whole is displaced backwards and upwards, and the anterior ligaments are torn. The method of reduction is indicated. *(After Böhler.)*

ments are torn (Fig. 270). Some degree of lateral dislocation usually occurs at the same time.

Reduction.—Accurate reduction is essential, as any uncorrected deformity, besides altering the statics of the ankle joint, predisposes to flat-foot afterwards, and permanent disability may result. No time should be lost in reducing the displacement, and the practice of waiting to allow swelling to subside must be strongly condemned. A general anaesthetic is usually employed. As a first step in the treatment, the swelling should be massaged away, until the hollows around the malleoli reappear. This may occupy 10 to 15 minutes, but the time spent is well repaid. Reduction of the swelling can be assisted by the application of a rubber bandage for half an hour or so prior to the massage. It is applied from the toes to the middle of the calf; the turns are first applied fairly tightly, but are placed with increasing slackness towards the upper part. The displacement is then reduced by the method shown in Fig. 271 B. Lateral dislocation is corrected if the foot is inverted by a hand placed around the heel.

The ball of the thumb presses firmly over the lateral malleolus, while the *finger-tips lie in the hollow behind the medial malleolus.* The other hand grasps the leg just above the ankle and presses it in the opposite direction. By this manoeuvre the dislocated talus is restored to its normal position, and displacement of the fibular fragment is reduced. Strong force may be used, as over-correction is unlikely. *Since the hand placed behind the heel supports the weight* of the lower leg, any posterior dislocation is likely to be corrected at the same time; if this displacement is marked, the foot is pulled strongly forward as part of the manipulation. The foot must be placed in right-angled dorsi-flexion, and for this purpose the knee should be flexed to permit relaxation of the gastrocnemius. Full dorsi-flexion is particularly necessary in cases of posterior dislocation, as the displaced fragment is then pulled down into position by the attachment of the posterior ligament (Fig. 270).

Immobilization.—It has been advised that the whole foot should be put up in the inverted position, in order to maintain reduction, and to prevent the subsequent development of flat foot. This is not only unnecessary but is actively harmful, as the longitudinal arch is then flattened out, and subsequent flat foot may thereby be produced. In the method of treatment illustrated (Fig. 271), inversion is obtained only in the posterior part of the foot, *i.e.* at the subtaloid joint; the fore part of the foot is relatively *everted*, so that the heads of the first and fifth metatarsal bones lie at the same level in a plane at right angles to the axis of the leg. *By this method the* fragments are retained in position, and the normal arch of the foot is not only restored, but is actually exaggerated (see also p. 300).

In the great majority of cases of Pott's fracture, an unpadded plaster cast can be applied without the risk of interference with the circulation, *for, in contrast to fractures of the lower leg,* where fleshy muscle may be torn, further swelling rarely occurs. There is undoubtedly more danger to the circulation than with a padded cast, but, if the plaster is carefully applied, and a careful watch is kept during the first twenty-four hours, the danger is relatively slight. In the method illustrated, a *circular* cast is employed. Although this is moulded closely to the contours of the limb, *the utmost care must be taken that the actual turns of bandage are applied slackly* (Fig. 272). *The skin is not shaved, as the incorporation of the hairs in the plaster* ensures more complete fixation. When the plaster is removed after the normal interval of eight or ten weeks, the hairs will come away painlessly in the cast. (If, however, for any reason the plaster should require to be removed within the first two or three weeks an anaesthetic may be necessary.)

The method of applying the plaster is illustrated in Fig. 271. After the fracture has been reduced, the position is maintained by an assistant who *holds* the entire foot in inversion by grasping the

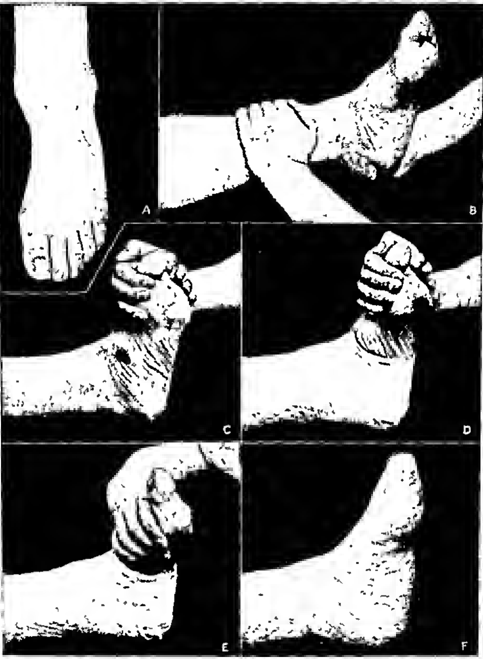


FIGURE 271

Pott's fracture.—Method of reduction and immobilization.
(*See description in text.*)

Note *that in the completed* **plaster cast, inversion** *is maintained only in the posterior* part of the foot. The fore foot is relatively *everted*, so that the heads of the first and fifth metatarsals lie in the plane of the ground. By this method, the longitudinal arch is fully restored.

fore-foot. By this grip he supports the weight of the leg, so that the foot tends to be pulled forward, and any backward displacement is corrected. The foot is maintained at a right angle, and to allow this the knee should be held flexed. Circular turns of plaster bandage are now applied to form a cast *extending only as far as the middle of the longitudinal arch*. It is completed up to the tibial tubercle, at which level the skin is protected by a ring of felt or lint. The lower edge of the cast at the middle of the foot is left thin. A few minutes are allowed to elapse for the plaster to harden. The fore-foot is then brought back to the horizontal plane. Inversion of the

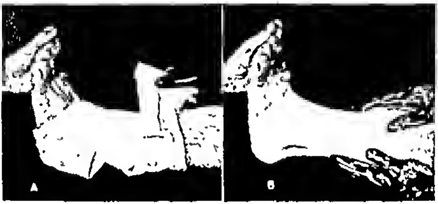


FIGURE 272

Method of application of an unpadded *circular* cast for Pott's fracture. The plaster bandages, especially those next the skin, are applied very slackly (A) The plaster may subsequently be moulded closely to the contours of the leg and ankle (B), *with little risk of constriction*.

posterior part of the foot will thus be retained while the normal arch is restored (Fig. 271 E and F). The edge of the partially completed cast, having been made thin, will bend with the foot and will not injure the skin. The cast is completed with the foot in this position. The fore-foot and toes are supported by a plantar slab, which is moulded below the transverse arch. Dorsally, the cast does not extend beyond the web.

In cases where considerable swelling is present, and cannot be satisfactorily reduced by massage, or when there is *blistering of the skin*, *a temporary padded cast* may be applied on the same lines. It is replaced by an unpadded cast in a week or ten days' time.

Malleolar fractures with dislocation.

Lateral dislocation.—As already described, a varying degree of lateral dislocation occurs in the typical Pott's fracture. Its treatment has already been considered.

Posterior dislocation is also common. It can usually be corrected by the method described. In some cases however where the fracture involves a larger part of the lower articular surface of the tibia,

it may be difficult to retain the fragment in position by plaster fixation alone. Continuous traction should then be employed in Böhler's lower leg splint, a pin or wire being passed through the calcaneum (Fig. 255). Such traction may be combined with plaster fixation (Fig. 256).

Central dislocation (Dupuytren's fracture). If the interosseous tibio-fibular ligament is torn, the talus may be forced upward between the leg bones (Fig. 273). Strong traction is required to reduce the displacement; for this screw traction (Fig. 261) is useful, but continuous traction may suffice. Reduction should be maintained by a split plaster cast combined with continuous traction (Figs. 263 and 264).

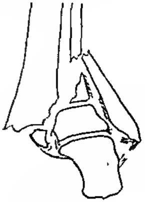


FIGURE 273

Dupuytren's fracture.

FIGURE 274

"Reversed" Pott's fracture.

Medial dislocation.—A fracture with medial dislocation is sometimes described as a "reversed" Pott's fracture, as it is produced by an *inversion* strain. Both malleoli are fractured, and these together with the foot are displaced medially. The principles of treatment are the same as in a Pott's fracture. The displacement is corrected by *eversion* of the heel and by strong lateral pressure over the medial malleolus, after which a plaster cast is applied. The medial malleolus may carry with it a considerable

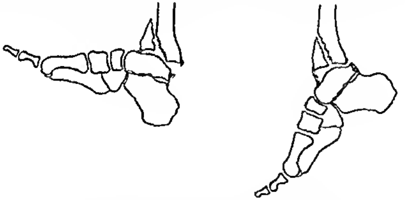


FIGURE 275

Malleolar fracture with anterior dislocation.

The fracture involves the anterior margin of the tibia. The fragment together with the foot as a whole is displaced forwards and upwards, and the posterior ligaments are torn. Note that reduction is obtained by strong plantar flexion, when the tension of the anterior ligament pulls the fragment into position. *(After Böhler)*

part of the lower articular surface of the tibia (Fig. 274). In such cases, reduction may be unstable and continuous traction should then be employed.

Anterior dislocation.—A fracture with anterior dislocation is a uncommon variety of "Pott's fracture." It results from a fall on the heel when the ankle is dorsi-flexed. A fragment is broken fro the anterior margin of the tibia, carrying with it part of the articul surface. This fragment together with the foot as a whole is displace forwards and upwards (Fig. 275). The deformity can be reduced b strong plantar-flexion, but fixation in this position is impracticab except for a very short period, and treatment is best carried out b continuous traction until consolidation occurs.

After-treatment.—After the application of plaster, the foot of th bed is elevated, or the limb is placed on the lower leg splint. Th nurse is instructed to keep a careful watch on the colour of the toe and the cast must immediately be split if any circulatory interferen is suspected. If the plaster has been carefully applied (Fig. 272 this necessity should never arise.

The ankle is re-X-rayed either immediately after the plast fixation or within the first twenty-four hours. Apart from the gener outline of the bones, two points in particular should be investigate in estimating the accuracy of reduction. Firstly, the lower articul surface of the tibia and the upper surface of the talus shou be equidistant throughout the width of the joint, and, secondly, th normal outline of the *articular* surface of the medial malleolus shou be restored (Fig. 276). If reduction is incomplete, the plaster mu be removed and a fresh manipulation carried out.

The "walking" plaster.—Fixation of fractures in plaster of Par formerly suffered the widespread criticism that joint stiffness an muscular wasting resulted from the prolonged immobilization. Th introduction by Böhler of the unpadded walking plaster cast mu be regarded as the greatest advance in fracture treatment with recent years, for to this method of treatment these criticisms canno be applied. Böhler has done much to prove his assertion that joi stiffness after fracture is due mainly to changes in the muscles. the patient is allowed to walk in his plaster cast, all the muscles con trolling the ankle and more distal joints of the foot are in continu activity. It is true that the muscles which act upon the ankle joi alone are prevented from shortening, but these undergo *isometric* con traction with each step. Such continued activity, by maintaining th tone of the muscles, is an adequate safeguard against subsequent join stiffness, and wasting of the muscles themselves is reduced to a minimum The unpadded cast ensures absolute control of the fracture, and, i the absence of wasting, this is maintained throughout the treatment.

The "walking iron" consists of a U-shaped metal bar, abou ¾-inch wide and ⅛-inch thick, which may be fitted with two ligh cross-pieces at its ends (Plate XXXVII). It is incorporated in the ca with its bend projecting two and a half inches beyond the heel. B its use, weight is transmitted equally through the whole plaster cas

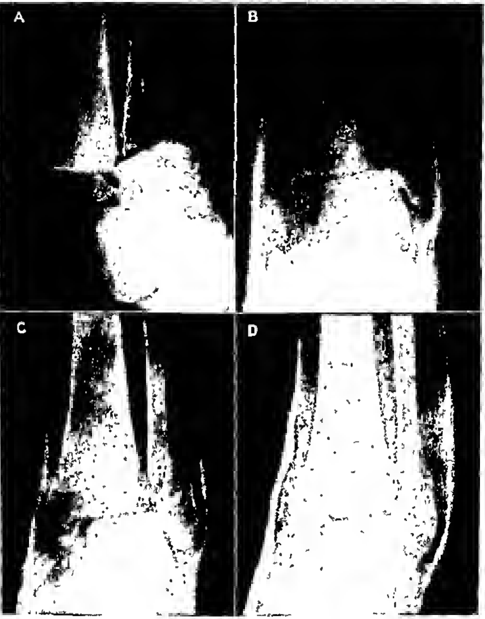


FIGURE 276

Antero-posterior radiographs showing a Pott's fracture with lateral dislocation, and the position after each of three successive attempts at reduction.

A.—The original injury. Note the extreme lateral dislocation.

B.—Reduction quite unsuccessful. (The appearances are now those of the average Pott's fracture with moderate displacement.)

C.—Position improved, but reduction still incomplete. Note obliquity of talus in relation to tibia, and displacement of medial malleolus as seen by the outline of its articular surface.

D.—The third attempt. Position now satisfactory. (The patient walked five miles eight days after this plaster cast was applied.)

difficult or impossible (Fig. 282), the surgeon should always supervise the completion of the walking plaster, and should make sure that the patient is walking satisfactorily before he leaves the hospital. If he is co-operative, it can almost be demanded of him that he walk without a limp!

SPRAINS OF THE ANKLE

A "sprained ankle" usually results from forcible *inversion* of the foot, and is due to tearing of the lateral ligament of the ankle joint. If the foot is plantar-flexed at the time of the injury, rotational strain is also present, as the leg tends to turn laterally on the fixed foot. The anterior, and less commonly, the middle bands of the ligament are torn. If the tear is in proximity to the fibular attachment, a radiograph may be necessary to exclude fracture.

The modern treatment of a sprained ankle is designed to provide support for the torn ligaments, while, at the same time, active use of the joint is encouraged. *Owing to the presence of effusion into the ankle joint, there is always a tendency for the foot to be held plantar-flexed, for in this position the capacity of the joint is greatest. If the foot is allowed to be retained for any length of time in the plantar-flexed position, the recovery of normal dorsi-flexion will be slow, and disability will be prolonged.* The old treatment of a sprained ankle consisted in the application of cold compresses, firm bandaging, and rest to the joint. These may still be recommended, *but only as a very temporary measure.* Firm bandaging of the ankle region always tends to promote plantar-flexion, and the use of crutches has a similar harmful effect. *Rest is only permissible if right-angled dorsi-flexion is maintained*; a splint or a light plaster cast may be used for this purpose.

Treatment by "stirrup" strapping.—Strapping is applied to the shaved leg in the form of a stirrup, which passes down one side of the leg and up the other; it extends upwards on each side to the level of the tibial tubercle, and should cover the malleoli. During the application, the foot is dorsi-flexed to a right angle, and for this the co-operation of the patient should be obtained (Fig. 284 A). The strapping should first be applied down the medial side of the leg; as it is brought up on the lateral side the maximum tension possible is obtained, so that the foot is pulled into eversion and the torn ligament is relaxed. In addition to such strapping applied in the long axis of the leg, it is an advantage to place one or more pieces obliquely in the line of the anterior band of the ligament. This strapping ("X" in Figs. 283 and 284) is applied to the limb in a spiral manner; it passes round the side of the base of the fifth metatarsal, and ends distally over the head of the first. In addition to allowing relaxation of the anterior band of the ligament, by controlling inversion of the fore-foot, it prevents cutting of the skin by the

anterior edge of the longitudinal strapping, where this passes round the lateral border of the sole. One or two circular turns should also be used to fix the strapping to the leg, but the front of the ankle joint should be left entirely free, as any constriction here tends to limit dorsi-flexion.

Treatment by ordinary adhesive strapping.—Strapping of 1-in. width is to be preferred. Two or three lengths are placed parallel and slightly overlapping to form the "stirrup," and an oblique band is applied in the line of the anterior ligament. Two further bands are brought forward round the malleoli, and two circular turns are used to secure the "stirrup" in the upper and lower thirds of the leg

FIGURE 283

"Stirrup" strapping applied for sprained ankle.

1" plain adhesive is used. The band "X" is placed in the line of the anterior fibres of the lateral ligament. Note that the front of the ankle joint is left free.

(Fig. 283). It is sometimes advised that the adhesive strapping should be covered with an "*Elastoplast*" type of bandage; this may reduce swelling and prevent slipping of the strapping, but as a rule it increases the discomfort owing to the constriction round the joint, and tends to limit dorsi-flexion, so that a normal action in walking is more difficult.

Treatment by elastic strapping.—If this type of strapping is favoured, the "orthopaedic" variety, which stretches *transversely* instead of longitudinally, should be employed, as elasticity in the longitudinal direction will permit stretching of the torn ligament, and the support provided is less adequate. It is applied in a manner similar to that described for ordinary adhesive. If 3-in. strapping is used, one width will suffice for the "stirrup" (Fig. 284).

Swelling around the lateral malleolus is effectively dispersed, if a U-shaped pad of felt is placed under the strapping in this situation (Fig. 284 A). If there is much effusion into the joint, swelling will appear also below the medial malleolus; this may be treated in a similar manner.

After-treatment.—After the strapping has been applied, the patient should be able to walk fairly comfortably, although, before

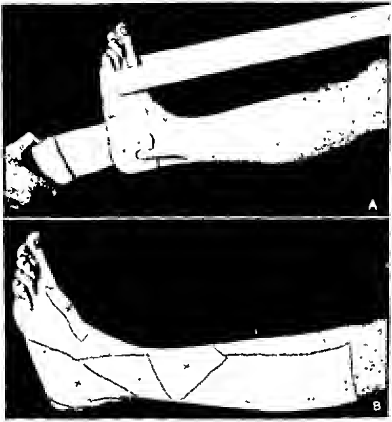


FIGURE 284

Alternative method of applying "stirrup" strapping using 3" *Flexoplast Orthopaedic strapping* (which stretches transversely).

A.—*Dorsi flexion is maintained by the patient, who pulls on a bandage passed under the fore-foot. A U-shaped pad of felt is placed around the malleolus to disperse swelling. The strapping is pulled tightly up the lateral side of the leg, to promote eversion of the foot.*

B.—The strapping completed. Note the length "X," which is placed spirally round the leg, and lies in line with the anterior band of the ligament.

treatment, he may have been unable to put his foot to the ground. The immediate relief of pain and the comfortable sense of support provided by the strapping have to be experienced to be appreciated. The patient is advised that, for a few days, the joint will be painful *after rest*, but that exercise will soon bring relief. In severe cases,

a dorsi-flexion splint should be applied at night; this will ensure much less discomfort on the following morning. Treatment is continued for 10 days to 3 weeks. The strapping will probably require to be changed after the first week, when the initial swelling will have subsided.

In exceptionally severe sprains, the patient may be unable to bear weight with the support of strapping alone. Such cases should be treated by a "walking" plaster cast (p. 234), in which walking should be possible without pain. If much swelling is present, the joint should be rested before plaster is applied, but dorsi-flexion must be maintained.

XX

FRACTURES OF THE CALCANEUM

FRACTURES of the calcaneum result from a fall on the heel. The fracture is a compression one, as the weight of the falling body is transmitted through the talus on to the upper surface of the calcaneum. In the commonest type of fracture, the talus is driven like a wedge into the calcaneum, and the resultant fracture is a somewhat formless comminution. Several different types of fracture are described. Those most commonly found involve the talo-calcanean joint, and the whole posterior process is displaced upwards in relation to the body of the bone, with resultant flattening

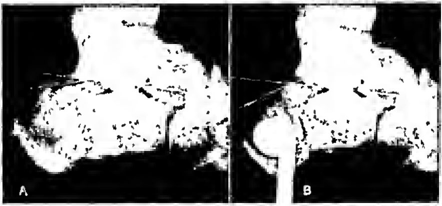


FIGURE 285

Lateral radiographs of fractured calcaneum with upward displacement of posterior process.

A.—Before reduction. Note lessening of salient angle.
B.—After reduction by skeletal traction. Angle restored.

out of the posterior part of the longitudinal arch. The amount of displacement may be estimated by a study of the "*salient angle*" *(Böhler), i.e., the angle between two lines drawn on a lateral radio*graph along the upper aspect of the calcaneum—one from the highest point to the anterior angle, and the other from the highest point to the upper part of the posterior process (Fig. 285). In the normal bone, this angle should measure 30 to 40 degrees. After a fracture, the angle becomes smaller, disappears entirely, or is reversed. The amount of displacement is estimated by comparing the angle with that of the uninjured side.

In addition to this flattening out, the calcaneum may be shortened by impaction or piling up of the posterior part. If this occurs, the bone is likely to be markedly broadened, by the breaking down of the

lateral wall, which is displaced outwards, and can be felt as a hard mass obliterating the normal hollow below the lateral malleolus.

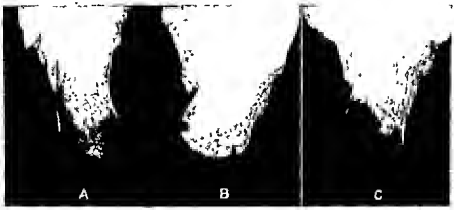


FIGURE 286

Axial radiographs of fractured calcaneum.

A.—Calcaneum of uninjured side for comparison.

B.—*Compression fracture, showing impaction of fragments, with* broadening of bone and breaking down of lateral wall.

C.—*The same after hammering to free impaction, followed by* side-to-side compression with redresseur.

Such broadening of the calcaneum is shown in an *axial* radiograph (Figs. 286 and 287), which outlines the lateral surfaces in profile.

The *treatment of fractures of the calcaneum* presents a considerable problem, and there is general agreement only as to the prevalence of unsatisfactory results. The necessity of restoring the normal shape of the bone is stressed by Böhler. This is usually difficult, in view of the extensive comminution present, and successful reduction is by no means a guarantee of a good functional result. Many surgeons advise that no attempt *should be* made to restore the normal architecture of the bone, claiming that the after-results are *equally good* if simple *immobilization* is carried out, and the bone is allowed to consolidate in its altered shape. It would seem reasonable, however, to believe that the best results are more likely to be obtained if the normal shape of the bone is at least partially restored, even though complete restoration may be impossible. Disorganization of the sub-taloid joint is the commonest cause of *disability*, and the changes in the joint surfaces must bear a definite relationship to any bony deformity which remains uncorrected.

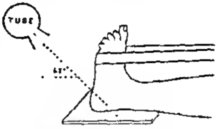


FIGURE 287

Method of obtaining "axial" radiograph of calcaneum.

Disimpaction.—The typical compression fracture is firmly im-

FIGURE 288

The method of hammering illustrated. Note how the lateral malleolus is protected by the surgeon's thumb

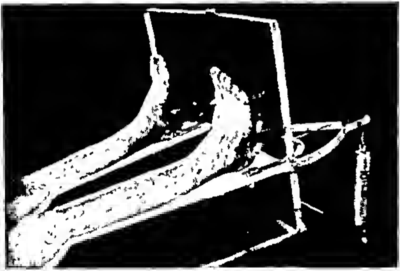


FIGURE 289

Bilateral fracture of calcaneum. Upward displacement treated by continuous traction in a double lower leg splint (Böhler's).

pacted, and the fragments must be freed before any attempt can be made to mould them into position. Disimpaction may be carried out by the method of *hammering*. The ankle is placed with its medial side resting on a sandbag, and well protected by padding. A thick felt pad is laid on the lateral aspect of the calcaneum just below the malleolus, and a number of sharp blows with a broad-faced hammer are directed on to this surface. The malleolus is adequately protected if the surgeon places his left thumb upon it (Fig. 288)! If disimpaction has been successful, the large posterior fragment can be moved about with the production of crepitus, and the broadening may be wholly or partly reduced.

Reduction of upward displacement.—Skeletal traction is usually necessary, and is obtained by means of a pin or taut wire. The

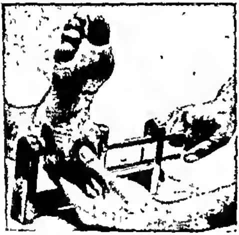


FIGURE 290

Broadening of calcaneum reduced by means of Böhler's redresseur.

FIGURE 291

Application of redresseur, while screw traction is maintained.

calcaneum should be transfixed well posteriorly, so that the traumatized area is avoided. *Screw traction* is most effective for the reduction of displacement, 40 to 60 lbs. being applied for a few minutes in the line of the lower leg (Fig. 261). Böhler advises that traction should be applied in the line of the posterior process. This necessitates transfixion of the tibia above the ankle, and the slinging of the leg by this means to the upright arch of the traction appliance. If the disimpaction has been adequate, such traction is not usually necessary; it may therefore be reserved for cases where obstinate displacement persists. *Continuous traction* is used to maintain the position after reduction by screw traction, or it may in itself be adequate to correct the upward displacement. Böhler's lower leg splint (Fig. 289) is used, and 10 to 15 lbs. weight is attached. Continuous traction is maintained for six to eight weeks, as, even in the absence of weight-bearing, upward displacement is liable to recur.

Reduction of broadening.—The broadening of the calcaneum, which is present in a large proportion of cases, may be corrected by the hammering originally employed to disimpact the fragments, or a special compression clamp or *redresseur* may be used. Böhler's redresseur is shown in Plate XXXIV, and in Figs. 290 and 291. The oval-shaped metal pad is applied to the lateral side of the calcaneum; the pad for the medial side has a semi-lunar shape, to allow for the projection of the sustentaculum tali. The clamp is rapidly tightened until the distance between the pads is shown on the scale to be 3·5 cm.—the width of the normal calcaneum in the area where pressure is applied. As rapidly, the pressure is relaxed. *The skin will not suffer if the operation is expeditiously carried out. It can be accomplished without difficulty within fifteen seconds.* In fractures which show both upward displacement and broadening, the *redresseur* should be applied at the same time as screw traction is being carried out (Fig. 291).

Immobilization.

In cases where there has been no broadening of the bone, the position may be maintained by continuous traction alone (Fig. 289), and the application of plaster is delayed for a week or ten days, when the initial swelling will have subsided, and a more lasting fit can be obtained.

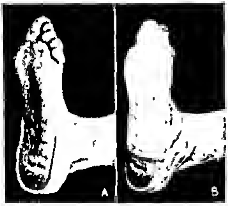


FIGURE 292

Plaster cast for fractured calcaneum, where broadening has been present.

A.—Slab of plaster moulded round sides and back of heel. *Malleoli protected by* small felt pads.

B.—Cast completed. Slackness around the calcaneum is at once apparent, and when a walking iron is added, no weight is borne on this bone.

In cases with broadening, which has been reduced by hammering or by compression, *a plaster cast* is immediately applied, and is moulded closely around the sides of the calcaneum (Fig. 292). This prevents a recurrence of the deformity, and reduces callus formation. If upward displacement has also been present, the cast must be moulded to the sides of the calcaneum with the traction wire *in situ*. As swelling subsides, the cast rapidly becomes loose-fitting around the heel, and requires to be renewed at intervals if re-displacement is to be prevented. It is impossible to assess the amount of slackness present if the heel is completely enclosed in plaster. The type of cast shown in Fig. 292 is particularly therefore useful, as the plantar surface of the heel is left exposed, and any slackness of the cast is at once apparent.

The correction of deformity is checked by lateral and axial radiographs taken after reduction. If displacement remains, further manipulation should be carried out—*e.g.* the amount of traction may be increased, or the *redresseur* may again be applied.

After-treatment.—An ordinary "walking" plaster cast should not be employed, as with this weight-bearing on the heel cannot be entirely prevented, and upward displacement will recur. If, however, a window is left over the heel (Fig. 293) it has been found that walking can safely be allowed. Contrary to what might be expected,

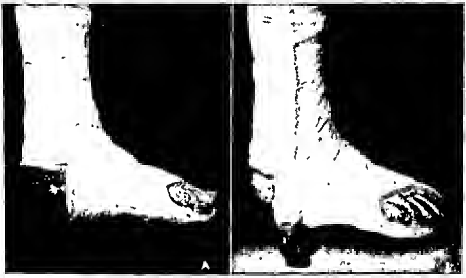


FIGURE 293

Walking plaster cast for fractured calcaneum. The window left over the heel prevents weight being borne upon it. If broadening of the bone has been present, the plaster is moulded closely to the sides of the heel, and only the plantar surface is left exposed (*Fig. 292*).

there is no complaint of pressure from the edge of the cast crossing the sole, nor does the heel become swollen.

Consolidation of the fractured calcaneum is not complete until from twelve to fifteen weeks after reduction. During this time, weight-bearing on the heel is prevented by the use of the special type of walking plaster described. If the patient exercises adequately, stiffness of the ankle joint and muscular wasting should not occur. The salient angle usually becomes smaller during consolidation of the fracture, but this alone does not appear to influence the ultimate result.

It is held that the prognosis depends upon the degree of damage to the sub-taloid joint, but, even in fractures of similar type, the period of disability varies unaccountably from a few months to several years. For patients who suffer persistent pain, a sub-taloid arthrodesis may be advised.

XXI

DEFORMITIES OF THE FOOT

CLUB FOOT (CONGENITAL TALIPES EQUINO-VARUS)

TALIPES equino-varus is the commonest type of congenital club foot. *In this condition, the heel is drawn up from* shortening of the tendo Achilles, and the foot is turned inwards to a varying degree so that the sole faces medially. At the same time, the fore-foot is adducted; the tubercle of the navicular comes to lie close to the malleolus, and the medial side of the foot is markedly concave. Only the lateral side of the foot, which is convex, *touches the ground, and on this the weight* is borne. The lower part of the tibia may be rotated medially.

FIGURE 294

Congenital club foot. (*Miss Hertfeld's case.*)

Treatment is designed to reduce the deformity, and to maintain the foot in the corrected position, until the soft tissues have become adapted, and muscular power has developed. Growth of the bones can then proceed along normal lines.

Correction of Deformity.—This should begin as early as possible. The methods of Dennis Browne are advocated.

In infants and young children up to the age of two years, the deformity can usually be corrected without difficulty by manual

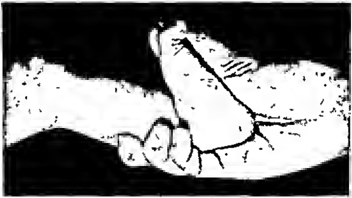


FIGURE 295

One-hand method of correction in infants and young children.

manipulation. The "one-hand" method is illustrated in Fig. 295. The palm is applied around the child's heel, while the four fingers curl

round the back of the ankle. The foot is forcibly dorsi-flexed and everted, till the little toe touches the anterior surface of the leg. The parents may be trained to carry out this manipulation several times daily. If it is conscientiously performed, the shortening of the tendo Achilles and of the structures on the medial side of the foot will gradually be overcome, and, in mild cases, no further treatment may be required.

After the age of two, the foot may be too stiff for manual manipulation to be successful. The "nut-crackers" devised by Browne may then be used. This appliance consists of two flat wooden boards hinged together by bolts with eyes at their ends which interlock. The patient's leg is strapped to the lower board, and the upper board is used as a lever to obtain extreme dorsi-flexion (Fig. 296). An

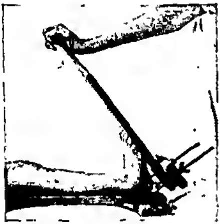


FIGURE 296
Correction with "nut-crackers."

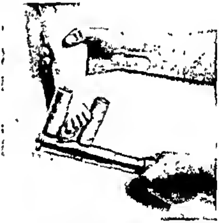


FIGURE 297
Correction with Thomas's wrench.

essential feature of the appliance is that the axis of the hinge must coincide with that of the ankle joint. By means of wing nuts on the bolts, it is possible to control the position of the hinges and the inclination of the upper board, so that a varying degree of eversion of the foot may be obtained.

An alternative method of manipulation consists in the use of a Thomas's wrench to obtain the forcible correction (Fig. 297).

Maintenance of the corrected position.—As a successful result is dependent upon satisfactory muscular development, the ideal method of splintage should maintain the corrected position without interfering with muscular activity. The splints advocated by Browne adequately fulfil this purpose (Figs. 298 and 299). They consist of two L-shaped aluminium plates, which can be bolted securely to a cross-bar of the same material. One limb of the plate is bent upwards at a right angle to lie against the *lateral* side of the leg, and is shaped to fit round the malleolus; the other limb lies horizontally and is

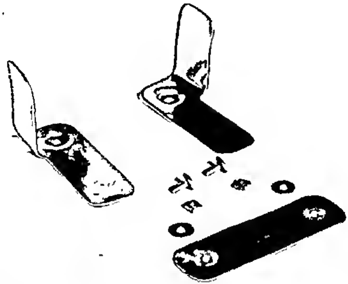


FIGURE 298
Browne's club-foot splints.
(*For description, see text.*)

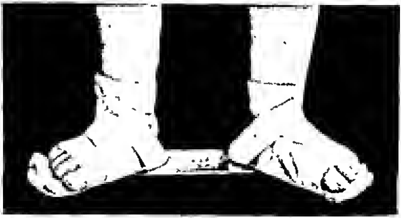


FIGURE 299
Browne's club foot splints in use. Note how dorsi flexion and eversion of the feet are obtained, and that their rotation is absolutely controlled

applied to the sole of the foot. Before being attached to the cross-bar, the splints are applied separately to the feet. For this 1-in. adhesive strapping is used. The fore-foot is first bound securely to the plate; a felt pad may be placed under its lateral border to increase the subsequent eversion. The strapping is then carried up to secure the vertical limb of the splint to the leg, when the full everting effect will be obtained. The splints are now fixed to the cross-bar, the nuts being tightened with a spanner. In bilateral cases, both feet are made to point outwards, up to the normal limit of 90 degrees. In unilateral cases, the normal foot is secured in 20 degrees of outward rotation.

The advantages claimed for this method of splintage are that it maintains not only the corrected shape of the feet, but also their

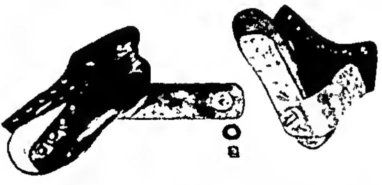


FIGURE 300

Special boots designed by Browne—for use after splints have been discarded.

(By kind permission of John Wright and Sons, Bristol)

normal *rotation* in relation to the lower legs and to the sagittal plane of the body as a whole. With plaster fixation such control is possible only if the cast is carried above the knee, and in infants and young children some degree of muscular wasting will result. When treated by the splints described, the child is encouraged to kick about, and to stand up as much as possible, so that wasting does not occur.

The treatment is continued for about nine months with fortnightly changes and re-manipulation. When the foot comes to be held at rest in the corrected position, Browne advises that the splints should be replaced by special boots (Fig. 300), which can be fixed in the same manner to the aluminium cross-bar. These boots have open toes, so that the child will not outgrow them. After a period of time depending upon the progress made, the boots are worn only during sleep or rest, and during the rest of the day the child is allowed to run about without restriction.

In older children, plaster fixation is to be preferred. The foot is immobilized in the over-corrected position, *i.e.* in the greatest possible

degree of dorsi-flexion, eversion and lateral rotation. In order that the rotation of the foot may be adequately controlled, the knee, which should be semi-flexed, is included in the cast (Fig. 301). If a walking iron is incorporated in the plaster, the child can walk or even run about with ease, so that muscular wasting is prevented. Owing to the flexed position of the knee, the iron is best applied at an angle to the lower leg, in the manner shown in Fig. 302. The

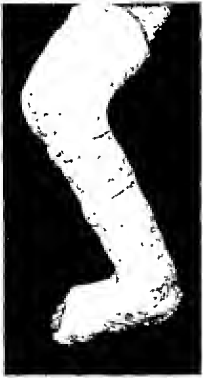


FIGURE 301

Plaster cast applied for talipes equino-varus in a boy aged four. The foot is immobilized in the over-corrected position of dorsi-flexion, eversion and lateral rotation, and the knee, which is flexed, is included in the cast.

FIGURE 302

If an iron hoop is incorporated in the cast in the manner illustrated, an excellent "walking" plaster results. This little boy ran about with complete unconcern and was seldom at rest.

length of iron which should project below the cast is determined by the degree of flexion at the knee. The first plaster cast applied after manipulation should be well padded to allow for swelling. After a few weeks, when ligaments and muscles have become relaxed, further correction in the position of the foot may be obtained without the use of force. A succession of unpadded or very lightly padded plaster casts may then be employed.

In obstinate cases which show persistent deformity, open operation

may be required. Operations advised include lengthening of the tendo Achilles combined with section of the posterior capsule, division or stripping of contracted soft structures on the medial side of the foot, and rotational osteotomy of the tibia. Such operations are usually followed by plaster fixation in the over-corrected position, and further treatment follows on the lines described.

The after-care demands constant supervision, as by all methods of treatment there is a tendency for the deformity to recur.

FLAT FOOT (PES PLANUS)

The term "flat foot" is used to describe the condition where there is a loss of the normal longitudinal arch. In early cases however (*incipient flat foot*), no such deformity may be evident, even when weight is borne, and the pain is then due to stretching of the ligaments which precedes actual bony displacement. In *non-resistant or voluntary flat foot*, flattening of the arch is apparent during weight-bearing, but the arch is restored when the foot is raised off the ground. In more advanced stages of the condition, the deformity persists in the absence of weight-bearing, and cannot voluntarily be corrected. In the *resistant* type, the normal attitude can be restored by manipulation, with or without anaesthesia, but in the *fixed* or *permanent* variety, the bones are so displaced or altered in shape, that correction is impossible without operation.

In established cases of flat-foot deformity, the longitudinal arch is markedly flattened, and the bones forming its summit, *i.e.*, the talus and navicular, come to lie nearer the ground. In addition, the talus is rotated medially, so that its head together with the navicular form a prominence on the medial side of the foot, which becomes convex in outline. The calcaneum is deviated into eversion or pronation, and the tendo Achilles becomes curved outwards towards its insertion. The fore-foot, *i.e.*, the part of the foot in front of the mid-tarsal joint, is abducted, and, in relation to the posterior part of the foot, it is also inverted or supinated. Such inversion of the fore-foot on the heel is an essential feature in the flattening out of the longitudinal arch.

Treatment is directed towards restoring and maintaining the normal arch of the foot. In mild cases, the weakened muscles and ligaments may be relieved of strain by rest, by strapping, and by the provision of correct or specially prescribed footwear. Their tone may be restored by exercises, massage, and other forms of physio-therapy. In the resistant type of flat foot, manipulation is necessary to restore the normal arch, and is usually followed by plaster fixation, so that the corrected position may be maintained.

Strapping.—This method, combined with rest, is of especial value in the treatment of acutely painful attacks, which may occur at any

time as the result of overuse or unusual strain, and in which the foot is oedematous and tender. The strapping gives a measure of support

FIGURE 303

Stirrup strapping applied for flat foot deformity. The strapping is pulled tightly upwards on the medial side so as to promote inversion of the foot. (3" *Elastoplast strapping is used.*)

to the foot, and is effective in relieving pain. It is applied in "stirrup" form, in a manner which will promote inversion of the foot (Fig. 303).

Footwear.—A correctly fitting shoe has a concave inner border, and is wide and roomy around the fore-foot. The waist is accurately

FIGURE 304

Shoe with medial side of heel raised by $\frac{1}{8}$"

FIGURE 305

"*Thomas heel.*"

The sole is elevated on the *lateral* side

FIGURE 305

moulded to give support to the arch, and the heel should fit tightly round the heel of the foot. A low broad heel should always be worn.

Specially prescribed footwear is designed to restore the normal *centre of gravity of the foot, by transferring the weight to the lateral side.* Inversion of the calcaneum is obtained by raising the heel $\frac{3}{16}''$ to $\frac{5}{16}''$ on the medial side. The "*Thomas heel*" has, in addition, a forward prolongation on the medial side, which gives support to the instep (Fig. 305). It is often advised that the sole should also be raised on the medial side, but in view of the fact that the fore-foot is inverted or supinated in relation to the heel, *any raising of the sole should be on the lateral side,* so that the normal relationship may be restored (Figs. 271 and 306).

FIGURE 306

Photograph of a normal foot to show how the longitudinal arch is exaggerated by *inverting* the calcaneum, and *everting* the fore-foot.

Manipulation.—Simple manual correction may be possible, but more forcible manipulation under anaesthesia is usually required. The arch may be restored by bending the foot over a wedge or sand-bag (Fig. 307), or by the use of a Thomas's wrench (Figs. 308 and 309). The foot is forcibly moved in all directions so as to stretch the shortened ligaments and to break down adhesions.

Plaster fixation.—This is usually employed after the arch has been restored by manipulation. The type of cast advised is similar to that described for the treatment of Pott's fracture (see p. 231). The heel is fixed in marked inversion, *but the fore-foot is brought back to the horizontal plane,* so that the normal arch is restored (Figs. 271 and 306). If, as is sometimes advised, the whole foot is placed in inversion, the longitudinal arch tends to be completely obliterated, and, when the patient attempts to walk after removal of the plaster, the fore-foot must immediately be everted in order to lie flat on the ground; the calcaneum will follow suit, since the foot moves as a whole, and the original deformity will have returned in its entirety.

FIGURE 307

Forcible manipulation of foot over a padded wedge.

A "walking" plaster is obtained by the incorporation of an iron stirrup in the cast (Fig. 277). The muscular activity which is then possible should contribute largely to a successful result. The cast

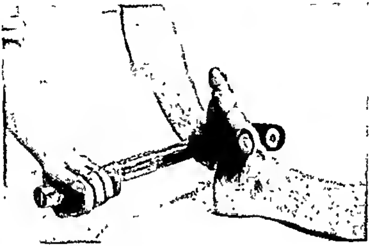


FIGURE 308

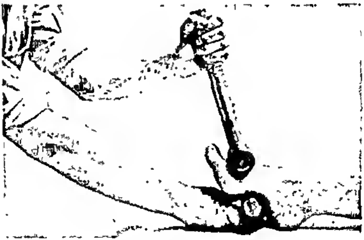


FIGURE 309

Forcible manipulation of flat foot, using a Thomas's wrench.

is worn for 8 to 10 weeks. After-treatment follows on the lines described for less severe cases.

Lateral iron and T-strap.—This is useful in cases where the eversion deformity is aggravated by spasm of the peroneal muscles. The iron rod fits into the heel of the shoe, and, at its upper end, is buckled to the leg immediately below the knee (Fig. 310). The T-strap is stitched at its base to the medial side of the shoe; when it is tightened round the iron, it prevents eversion of the foot.

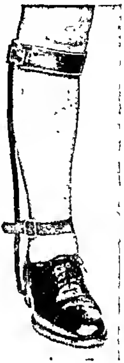


FIGURE 310

Lateral iron and T strap, used for spastic flat foot.

CLAW FOOT (PES CAVUS)

In this deformity, the longitudinal arch of the foot is exaggerated, and the metatarsal bones incline towards the ground at a much steeper angle than normally. This "dropping" of the metatarsal heads leads to clawing of the toes, and "hammer-toe" deformity is common. There is marked contraction of the plantar fascia and of the short muscles of the sole. The tendo Achilles is shortened, so that a varying degree of equinus deformity is present.

FIGURE 311

Claw foot. (*Mr. R. I. Stirling's case.*)

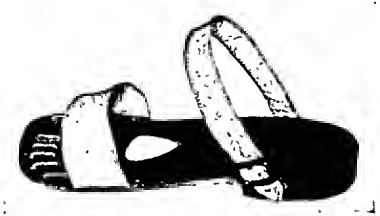
Treatment is designed to reduce the abnormally high longitudinal arch and to correct the clawing of the toes.

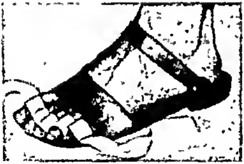
FIGURE 312

Manipulation of claw foot, using a Thomas's wrench.

Manipulation.—In mild cases, manipulation alone may be sufficient to correct the deformity. In infants and young children, manual manipulation may suffice; in older patients, a Thomas's wrench may be employed. It is used as shown in Fig. 312. More often, manipulation is combined with operations in which the contracted soft structures are divided.

Footwear.—Suitable footwear should be prescribed. The shoe must be of adequate length for the foot; the heel should be as low as the shortened tendo Achilles will permit, and its height is reduced at intervals. A metatarsal bar applied to the sole (Fig. 310) will reduce the pressure on the heads of the metatarsals, and will relieve symptoms of metatarsalgia. In order to correct incipient clawing of the toes,





FIGURES 313 AND 314

Special sandal for use in claw foot. The toes are straightened out by being bound down with tape passed through flat staples in the sandal. A sponge rubber metatarsal pad is also shown; this was used to relieve symptoms of metatarsalgia. (*Made up by J. Gardner & Son.*)

special sandals are useful (Figs. 313 and 314). By an arrangement of tapes, the toes can be strapped down to the flat surface of the sole.

Plaster fixation.—This is advised after manipulation, or after any one of the numerous operations described for the treatment of more advanced cases. The equinus deformity is corrected by immobilizing the ankle at a right angle, and, as far as possible, the longitudinal arch is flattened out by pressing up the heads of the metatarsals. As pressure sores are liable to occur over these bony points, adequate padding should be provided. The deformity of pes cavus is usually associated with symptoms of metatarsalgia, so that, when plaster is applied, an attempt should be made to restore the anterior or

transverse arch. This is done by moulding the plaster so that it is markedly hollowed out under the balls of the toes (Fig. 315).

FIGURE 315

Plaster cast for claw foot. The toes are straightened out and plantar-flexed. The cast is moulded under the transverse arch.

ANTERIOR FLAT FOOT (METATARSALGIA)

The anterior or transverse arch of the foot is found under the heads of the metatarsal bones. It is a matter of controversy as to whether this arch is present during weight-bearing. It would probably always be present if weight were borne with the heel flat on the ground. If high heels are worn, it is invariably obliterated, as an abnormal proportion of the weight is then transferred to the fore-foot.

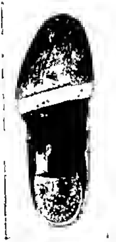


FIGURE 316

Shoe fitted with metatarsal bar.

Metatarsalgia, or pain in the region of the balls of the toes, is usually associated with anterior flat foot. In this condition, the transverse arch may not actually have "dropped," but the fore-foot is visibly broadened, due to splaying out of the metatarsals. The deformity is much more common in women, and is due largely to the wearing of high heels. Painful callosities may be present under the heads of the second and third metatarsals.

The object of treatment is to reduce the proportion of weight borne on the fore-foot, and to restore and *maintain* the *transverse* arch.

Footwear.—A low heel is the first essential, so that strain on the fore-foot may be relieved. Pressure on the heads of the metatarsals is prevented by a *metatarsal bar* (Fig. 316) attached

to the sole of the shoe. This is a bar of leather about ¾" wide and ¼" thick, which is attached obliquely to the sole below the *necks* of the metatarsals. It is a common mistake (for which surgeons and shoemakers are equally responsible) to affix the bar too far forwards on the sole. It then serves only to increase the pressure against the metatarsal heads, so that symptoms are aggravated. The bar must

FIGURE 317

Felt pad and strapping applied for metatarsalgia. The pad is placed below the *necks* of the 2nd and 3rd metatarsals

be affixed well back on the shoe—*at the posterior margin of that part of the sole in contact with the ground.*

Metatarsal pads.—Pads made of felt or sponge rubber are useful in restoring the transverse arch, and in relieving pressure on the heads of the second and third metatarsals. The pad is placed under the *necks* of these bones (Fig. 313). It may be attached to a leather in-sole worn within the shoe, or, as a more temporary measure (Fig. 317), it may be bound to the foot by adhesive strapping.

Plaster fixation.—This may be called for in severe cases. The toes are straightened out and plantar-flexed, and the transverse arch is exaggerated by moulding of the cast (Fig. 315). By the incorporation of an iron hoop (Fig. 277), a "walking" plaster cast is obtained.

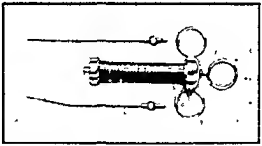
APPENDIX

INSTRUMENTS AND APPLIANCES

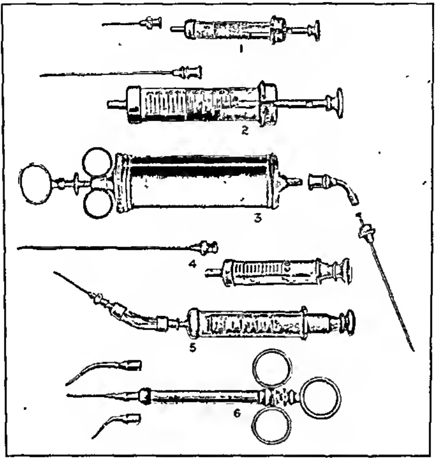
(Most of the plates in this section have been compiled from material kindly provided by J. Gardner & Son, Edinburgh, by Down Bros. Ltd., London, and by Chas. Thackray & Co., Leeds.)

PLATE I

1. **1 c.c. hypodermic syringe.**
2. **10 c.c. "serum" syringe**—also used for injection of local anaesthetic, or for aspiration.
3. **All-metal syringe for local anaesthesia**—fitted with interchangeable Schimmel's needles. The intermediate curved mount may be fitted to the syringe by screwing, as illustrated, or, more conveniently, by a bayonet catch which is fixed by a half-turn of the mount.
4. **Pitkin's syringe for spinal anaesthesia.** The needle locks on to the mount.
5. **All-glass varicose vein syringe** (Cellan Jones's). The small glass bulb placed between the syringe and the needle allows blood to be aspirated from the vein, without obscuring the solution in the main part of the syringe.
6. **Gabriel's haemorrhoid syringe.** This all-metal syringe is used for the *low injection* method of treatment, whereby a few minims of sclerosing solution are injected into each pile.



Harvey's haemorrhoid syringe—used for the method of *high injection*, 3 to 10 c.c. of solution being injected into the sub-mucosa of the rectum *above* each pile group. The needle is short but is mounted on a long stem.

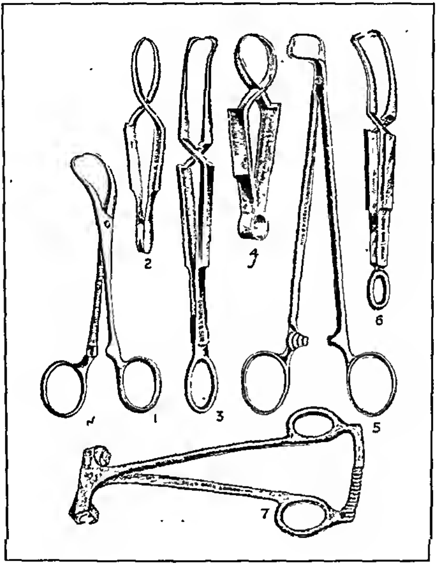


I.—SYRINGES

PLATE II

1. Backhaus's towel clip.
2. Gray's towel clip.
3. Doyen's towel clip.
4. Mayo's towel clip.
5. Moynihan's towel clip.*
6. Doyen's towel clip.*
7. Upcott's towel clip.*

* Used generally for the attachment of *side towels* to the edges of the wound.



II.—TOWEL CLIPS

PLATE III

1. **Bard-Parker knife**—handle with detachable blade. A large selection of blades, of different shapes and sizes, is available.

2. **Scalpel—London pattern.**

3. **Stiles's scalpel.**

4. **Syme's abscess knife**—used for opening abscesses by the method of transfixion.

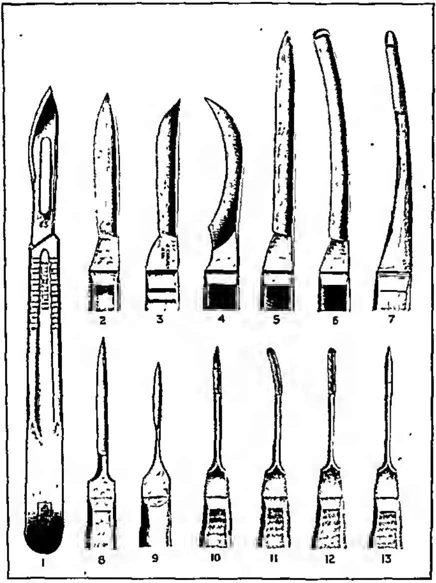
5. **Straight sharp-pointed bistoury.**

6. **Curved probe-pointed bistoury.**

Bistouries have long, narrow blades of uniform width. They may be used in performing small amputations, as of fingers or toes, and for laying open sinuses and fistulae.

7. **Hernia bistoury.** This is used in conjunction with a *hernia director* (Plate XI), for the division of the constriction at the neck of a strangulated hernia. It is probe-pointed, and the cutting edge is reduced in length in order to avoid injury to other structures.

8 to 13. **Tenotomy knives**—straight or curved, sharp- or probe-pointed, and double edged. Devised for the operation of subcutaneous tenotomy.



III.—KNIVES

PLATE IV

1. **Mayo's straight surgical scissors.** These have tapered but not sharp points, so that they can be used for blunt dissection.

2 & 3. **Surgical scissors—curved and angled on the flat.**

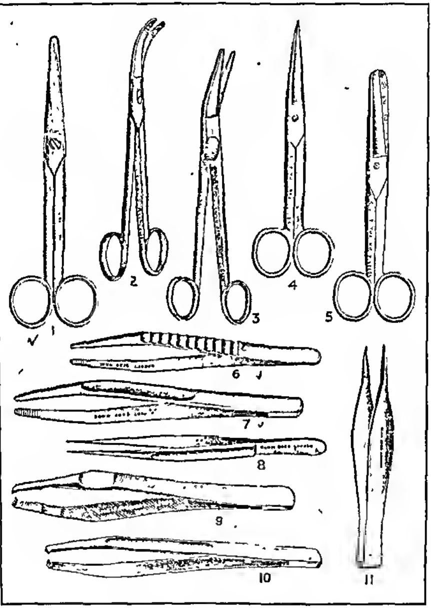
4. **Sharp-pointed scissors—"** stitch scissors."

5. **Blunt-pointed scissors—"** dressing scissors."

6 to 8. **Coarse and fine dissecting forceps without teeth.** Used for handling delicate structures, such as bowel, blood vessels and nerves.

9 & 10. **Dissecting forceps with teeth.** Lane's (9) are serrated for holding needle. These forceps are used for all general purposes, especially for holding and retracting skin flaps.

11. **" Splinter " forceps.** These are fine pointed but take a firm grip.



IV.—SCISSORS AND DISSECTING FORCEPS

PLATE IV

1. **Mayo's straight surgical scissors.** These have tapered but not sharp points, so that they can be used for blunt *dissection.*

2 & 3. **Surgical scissors**—curved and angled on the flat.

4. **Sharp-pointed scissors**—"stitch scissors."

5. **Blunt-pointed scissors**—"dressing scissors."

6 to 8. **Coarse and fine dissecting forceps without teeth.** Used for handling delicate structures, such as bowel, blood vessels and nerves.

9 & 10. **Dissecting forceps with teeth.** Lane's (9) are serrated for holding needle. These forceps are used for all general purposes, especially for holding and retracting *skin flaps.*

11. **"Splinter" forceps.** These are fine pointed but take a *firm grip.*

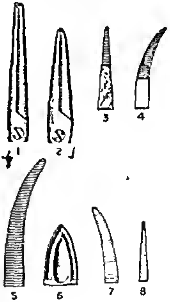
PLATE V

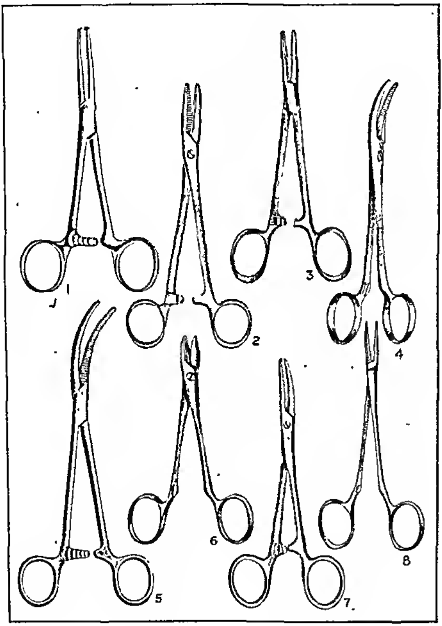
Artery forceps were designed for the purpose of preventing or arresting haemorrhage at operation. Either the vessel alone or a piece of tissue containing the bleeding point may be clamped. Artery forceps so applied are "tied off"—either *immediately* or *before the end of the operation*. *For this*, the forceps is held as nearly horizontal as possible by the assistant, while the surgeon ties catgut or silk around the vessel or tissue which has been clamped. Smaller vessels may remain occluded without ligature, as the result of the pressure alone.

Artery forceps have, however, innumerable other uses—the holding of ligatures and the edges of aponeuroses or peritoneum, and the clamping of pedicles.

There are many different types of such forceps, of which only a few are shown here.

1. Kocher's (Ochsner's).
2. Spencer Wells's.
3. Crile's.
4. Moynihan's.
5. Mayo's.
6. Greig Smith's.
7. Dunhill's.
8. Halstead's ("Mosquito").



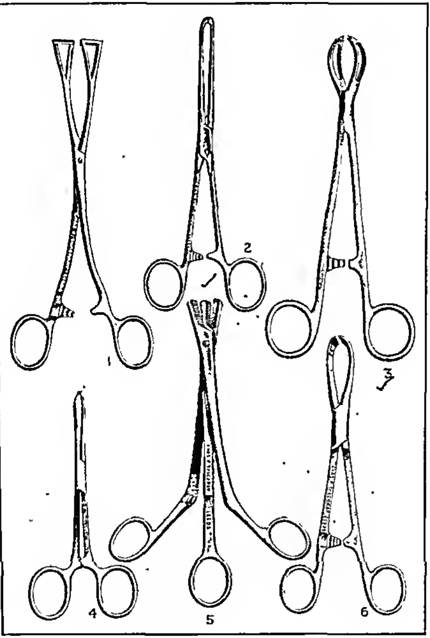


V.—ARTERY FORCEPS

PLATE VI

Tissue forceps are designed to take a firm but non-crushing grip. In general, their blades approximate only at the tips, where they are reinforced by teeth. They are used mainly for holding and retracting the cut edges of various tissues—skin, fascia, aponeurosis, peritoneum, etc.

1. **Duval's tissue forceps.** Only the distal edges of the triangular blades meet. This edge has fine teeth upon it.
2. **Allis's tissue forceps.** This is a most popular forceps, which is in very wide use. At the ends of the blades are three and four teeth which interlock. They inflict the minimum of trauma on the tissue, and can be used for holding bowel. Hence, they are sometimes called "*anastomosis forceps*."
3. **Lane's tissue forceps.** These take a very firm grip, but are liable to traumatize. They are used for edges of skin and aponeurosis.
4. **Poirier's tissue or peritoneum forceps** are somewhat similar to Allis's forceps. They usually have one and two teeth at the ends of the blades.
5. **Pannett's peritoneum forceps** are used to facilitate the suture of the peritoneal incision. The middle blade keeps the peritoneal edges slightly apart, so that the surgeon can see that his needle does not injure subjacent bowel.
6. **Rutherford Morison's tissue forceps** are intermediate in strength between Allis's and Lane's forceps. Littlewood's forceps are very similar, but the blades are rather more slender, and have fewer teeth.



VI.—TISSUE AND PERITONEUM FORCEPS

PLATE VII

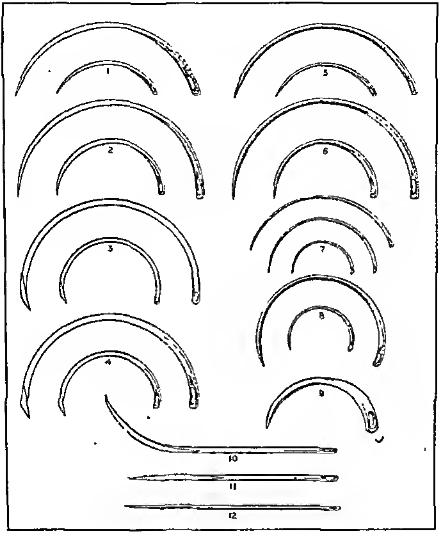
Needles are classified according to both shape and cross-section. Their shape may be straight, half-curved, or curved, and in cross-section they may be round, triangular, or of a special type (*Hagedorn*), in which the needle is flattened from side to side (*i.e.* in the opposite plane to that of the curve), and has a spear-shaped point. *Hagedorn* needles are particularly comfortable to the fingers, but they cannot be held in the ordinary needle holder; for this purpose, a *reversed Hagedorn needle is available, in which the half of* the needle towards the eye is flattened in the opposite plane from the rest. (*Plate VIII.*)

Curved needles may be $\frac{3}{8}$*-circle*, $\frac{1}{2}$*-circle*, $\frac{5}{8}$*-circle*, etc.

Triangular needles are used chiefly for skin suture, as the edges have a *cutting* action, which enables the needle to slip through more easily. *Hagedorn* needles, because of their spear point, are equally suitable for skin suture. Neither of these needles must be used for stitching delicate structures such as bowel, blood vessels or nerves. For these, round-bodied needles should be employed: the more slender round-bodied needles are frequently referred to as *intestinal* needles.

1. **Triangular $\frac{3}{8}$-circle needles.**
2. **Triangular $\frac{1}{2}$-circle needles.**
3. **Hagedorn needles.**
4. **Reversed Hagedorn needles.**
5. **Round-bodied $\frac{3}{8}$-circle needles.**
6. **Round-bodied $\frac{1}{2}$-circle needles.**
7. **Intestinal needles—$\frac{3}{8}$- and $\frac{1}{2}$-circle.**
8. **Round-bodied $\frac{5}{8}$-circle needles.**
9. **Gallie's fascial suture needle.***
10. **Triangular half-curved needle.**
11. **Triangular straight needle.**
12. **Round-bodied straight needle.**

* For use with a strip of fascia lata as suture material.



VII.—SUTURE NEEDLES

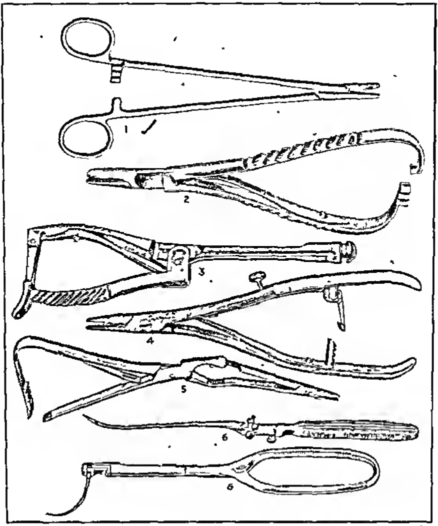
PLATE VIII

Needle holders are characterized by the possession of long handles and short blades, so that a firm grip is obtained. The blades are often slightly hollowed or are split, to avoid the straightening out of a curved needle. Many different types of ratchet are employed.

Reverdin's handled needles are of complicated structure. The eye can be opened by a spring shutter which is operated by a lever on the handle. In this way it can be "threaded" by pressing the suture material into it from the side.

1. **Mayo's needle holder.**
2. **McPhail's needle holder.**
3. **Hagedorn needle holder.***
4. **Harris's needle holder.**
5. **Halstead's needle holder.**
6. **Reverdin's handled needle.**
6. **Reverdin's handled needle, angled.** (Bonney's modification.)

* The blades are placed in the opposite plane from the normal, so that Hagedorn needles can be held.



VIII.—NEEDLE HOLDERS REVERDIN'S NEEDLES

PLATE IX

1. **Aneurysm needle.** This is curved in one plane only; the blade is flattened, and is completely blunt at the tip. It is used for passing ligatures round vessels, and owes its name to the employment of such measures in the treatment of aneurysm.

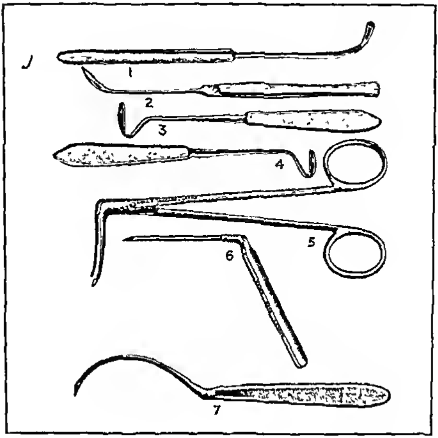
2. **Pedicle needle.** This is similar to an aneurysm needle, but the point, although relatively blunt, is finely tapered. It is used for the transfixion of a pedicle as a preliminary to ligation. As haemorrhoids may be treated by this method, it may also be known as a "*pile needle.*"

3 & 4. **Macewen's hernia needles.** These are curved in two planes and are blunt at the tip. They are used for the transplantation of the stump of the hernial sac under cover of the conjoined tendon, and for suture of conjoined tendon to inguinal ligament. The curve is in the opposite direction for right- and left-sided operations (Nos. 3 and 4 respectively).

5. **Cleveland's pedicle needle.** This is used for transfixing a pedicle, passing ligatures round vessels, etc. The slender *blades grip the ligature* material.

6. **Suture guide.** This consists of a large bore needle mounted on a handle. It is useful for guiding suture material through a hole which has been drilled in bone—as in the operation for fractured patella.

7. **Doyen's handled needle.** This is essentially a skin-cutting needle, as it has a spear-shaped point. It is used for the insertion of deep stitches in the abdominal wall.



IX.—HANDLED NEEDLES

PLATE X

Metal clips may be used instead of stitches for the approximation of skin edges. Accurate co-aptation is readily secured, and provided they are removed *not* later than the fourth day, little or no scarring is produced.

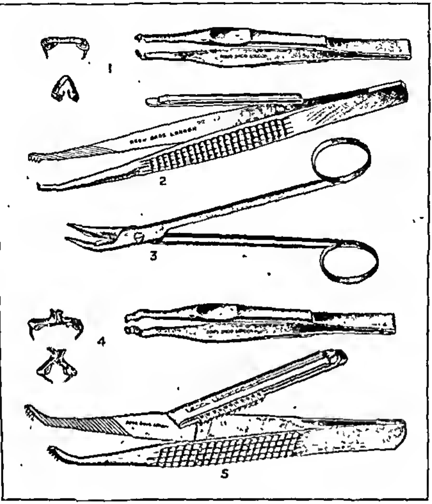
1. **Michel clips**—showing shape before and after insertion, and **introducing forceps.** The forceps resemble ordinary dissecting forceps, but there is a *clear-cut groove* at the point of each blade for holding the clip.

2. **Childe's dissecting forceps**—for approximating skin edges, with magazine for holding Michel clips.

3. **Michel clip extractor.** The lower blade is inserted below the head of the clip. When the blades (which are V-shaped) are closed, the clip is straightened out.

4. **Kifa clips.** These are very similar to Michel clips, but they are fitted with flanges so that they can be opened out and removed by pressure with dissecting forceps. They are not destroyed by removal and can be used again. **Introducing forceps** for Kifa clips are " bow-legged " near the tips, so as to circumvent the flanges on the clips.

5. **Dissecting forceps, with magazine for Kifa clips.**



X.—SKIN CLIP INSTRUMENTS

PLATE XI

Probes are used for various purposes—chiefly to explore sinuses, to detect their extent, direction and contents.

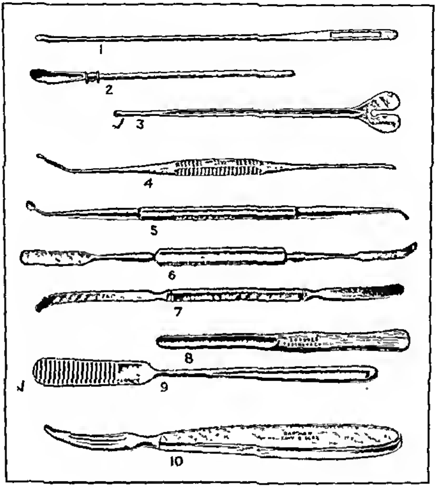
Directors are narrow blunt-pointed instruments, with a groove on one side, along which a bistoury may be passed. They are used mainly for laying open a sinus or fistulous track. *Hernia directors* are used to guide the knife to the constricting band at the neck of a strangulated hernia, and to protect the bowel during this manoeuvre. They are broader and have a shallower groove than the ordinary director.

Dissectors are used to separate the tissues covering a structure to which the surgeon desires access; they are usually blunt-pointed to avoid injury to vessels and nerves.

1. Simple probe.
2. Probe and scoop.
3. Brodie's fistula probe-director.*
4. Watson Cheyne's probe and dissector.
5. Stiles's probe and sharp spoon.†
6. Macdonald's aneurysm needle and dissector.
7. Miles's dissector.
8. Spence's hernia director.
9. Key's hernia director.
10. Kocher's dissector or "goitre enucleator."

* Fitted at one end with a "frenum slit," which was formerly used to protect the tongue during the snipping of the frenum for "tongue-tie."

† Used in mastoid operations.



XI.—PROBES, DIRECTORS AND DISSECTORS

PLATE XII

The smaller retractors are referred to as muscle retractors; they are used to hold apart the edges of the wound during operation. The larger retractors (abdominal retractors) are employed to hold aside certain organs (*e.g.* small intestine), while access is obtained to deeper structures. Bladder retractors usually have a characteristic curve to the blades; they are used to hold apart the edges of the incision in the bladder wall, during operations upon the interior.

1 to 5. Muscle retractors.

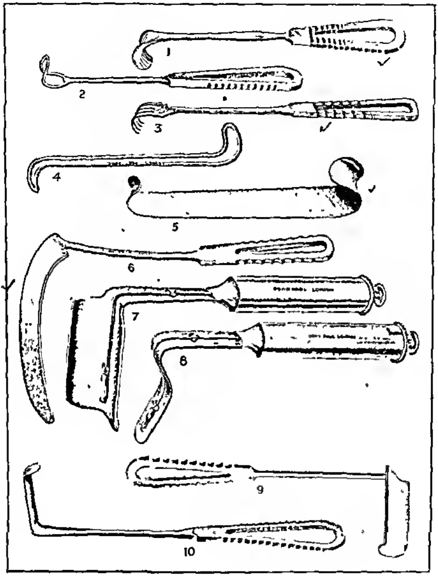
6. Kelly's abdominal (gall bladder) retractor.

7. Upcott's illuminated retractor.

8. Thomson-Walker's illuminated bladder retractor.

9. Morris's retractor.

10. Langenbeck's retractor.



XII.—RETRACTORS

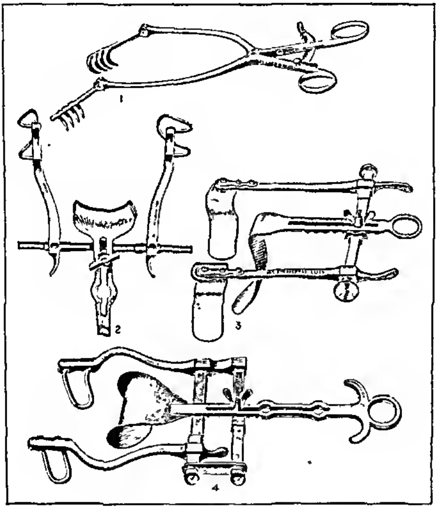
PLATE XIII

1. Mayo's thyroidectomy retractor.

2. Phillip's three-bladed abdominal retractor.

3. Thomson-Walker's bladder retractor.

4. Balfour's three-bladed abdominal retractor.



XIII.—SELF-RETAINING RETRACTORS

PLATE XIV

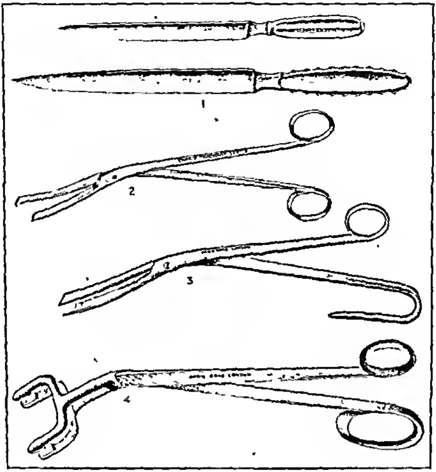
1. **Amputating knives.** These were very necessary instruments, when amputations were performed without anaesthesia. The operation was carried out against time, and the tissues were divided down to the bone with one sweep of the knife. In some cases, one flap was cut by transfixion—the knife was plunged through the limb close to the bone, and the flap was cut from within outwards.

2 to 4. **Sterilizer forceps.** These are used for lifting instruments out of the sterilizer, and for the carrying of instruments and dressings by an assistant who is not "scrubbed up." The blades of the instrument are kept sterile by being immersed in a jar of antiseptic.

2. Cheatle's forceps.

3. London Hospital pattern.

4. Harrison's basin holders.



XIV.—AMPUTATING KNIVES STERILIZER FORCEPS

PLATE XV

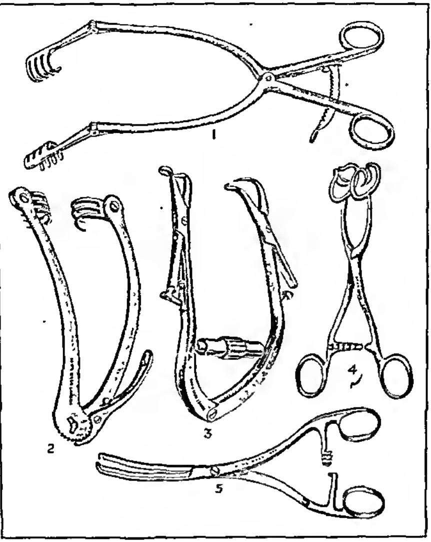
1. Mayo's self-retaining goitré retractor.

2. Kocher's self-retaining goitre retractor.

3. Joll's self-retaining goitre retractor.

4. Kocher's thyroid gland holding forceps.

5. Kocher's isthmus (thyroidectomy) clamp.



XV.—THYROIDECTOMY INSTRUMENTS

PLATE XVI

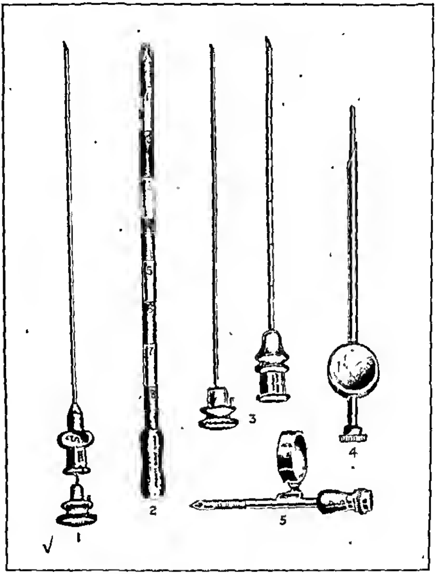
1. **Lumbar puncture needle (Pitkin's).** The stilette is ground at its tip to lie flush with the bevel of the needle. Rotation of the stilette is prevented by means of a pin which fits into a slot in the needle mount.

2. **Ventriculography needle.** This is blunt-pointed and graduated in centimetres. For the carrying out of ventriculography, the needle is inserted through a small trephine hole in the parietal bone into the posterior horn of the lateral ventricle. The cerebro-spinal fluid is replaced with air or oxygen, which outlines the ventricle on radiographic examination.

3. **Cistern puncture needle.** This is similar to a lumbar puncture needle, but is somewhat shorter, and is graduated in centimetres. It is used for aspirating fluid from, or estimating the pressure in, the cisterna magna.

4. **Graham's blood transfusion needle**—for withdrawal of blood from donor.

5. **Graham's blood transfusion needle**—for administration of blood to recipient. The part of the needle which enters the vein is milled: this prevents it from slipping when it is secured by a ligature.



XVI.—SPECIAL NEEDLES

PLATE XVII

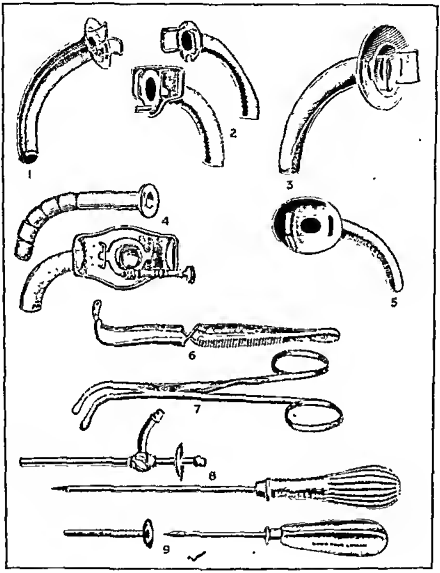
Tracheotomy tubes are of various patterns. They all consist of an inner and an outer tube, the former a little longer than the latter. The outer tube is held in position by tapes passed through the slits in its shoulder, and tied round the patient's neck. The inner tube must not be fixed.

Tracheal dilators are used to dilate the incision in the trachea in order that the tube may be inserted.

A cannula is a hollow tube used for aspirating the fluid content of an organ, or for removing collections of fluid from serous cavities or tissue spaces where it has collected. A trocar is a sharp-pointed stilette which fits closely into the cannula, with the point projecting beyond its end; it enables the cannula to be thrust into the cavity.

1. **Edinburgh pattern tracheotomy tube.**
2. **Parker's tracheotomy tube.**
3. **Fuller's bi-valve tracheotomy tube.**
4. **Durham's "lobster-tail" tracheotomy tube.**
5. **Laryngotomy tube.***
6. **Luer's tracheotomy dilator.**
7. **Trousseau's tracheotomy dilator.**
8. **Abdominal trocar and cannula, with side tube.**
9. **Hydrocele trocar and cannula.**

* Note the oval shape on cross-section, and the absence of an inner tube.



XVII.—TRACHEOTOMY AND LARYNGOTOMY TUBES
TRACHEOTOMY DILATORS, TROCARS AND CANNULAE

PLATE XVIII

1. **Cleft palate knife**—used for the cutting of the mucoperiosteal flaps.

2. **Trelat's cleft palate raspatory** } —for elevation of the flaps.
3. **Fraser's cleft palate raspatory** }

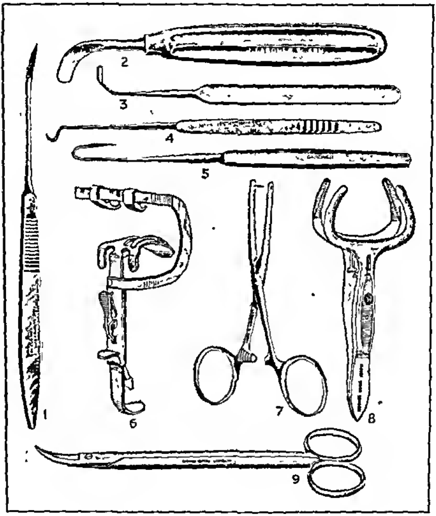
4 & 5. **Cleft palate needles**—for suture of the separated flaps in the mid-line.

6. **Dott's modification of Boyle-Davis gag.**

7. **Fraser's hare lip clamp**—used in pairs, one at each side of the lip, for the control of haemorrhage at operation.

8. **Smith's hare lip clamp.**

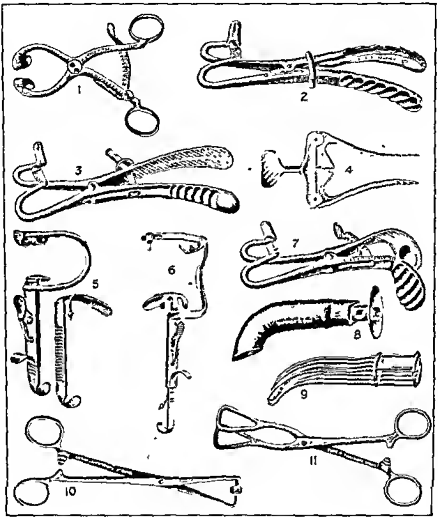
9. **Cleft palate scissors.**



XVIII.—HARE LIP AND CLEFT PALATE INSTRUMENTS

PLATE XIX

1. Doyen's gag.
2. Ferguson's gag.
3. Mason's gag.
4. Newington's mouth opener.
5. Boyle-Davis gag.
6. Dott's modification of Boyle-Davis gag.
7. Buxton's gag.
8. Phillip's airway.
9. Mayo's airway.
10. Thompson's tongue forceps.
11. Guy's tongue forceps.



XIX.—GAGS, AIRWAYS AND TONGUE FORCEPS

PLATE XX

1. **Foulis's tourniquet.** The stretched rubber tubing is held in a groove in the wooden block.

2. **Esmarch's tourniquet.** Fixation is secured between the hook at one end of the tubing, and a link of the chain at the other.

3. **Samway's tourniquet.** One end is fitted with an anchor-shaped hook, around which the stretched rubber tubing is fixed.

4. **Godwin's all-metal tourniquet.** The metal slip-knot is pulled as tight as possible, and further tension is obtained by means of the screw. It can be gradually released.

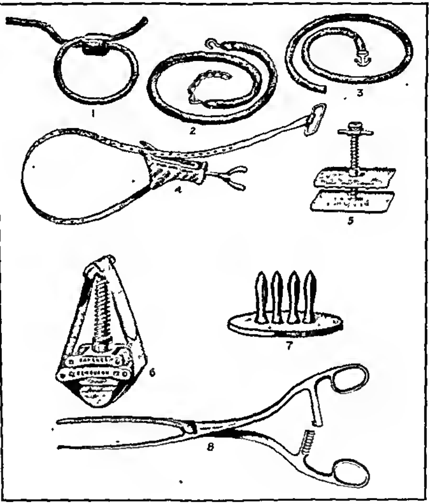
5. **Putti's tourniquet.** This consists of two metal plates, the upper of which is raised from the lower by means of a screw. If these are firmly bandaged to the limb, a tourniquet action is obtained.

6. **Petit's tourniquet.** This consists of a screw windlass around which strong webbing is passed. The webbing is buckled round the limb, and the tension is increased by turning the screw. (This illustration does not indicate the method of use of the tourniquet; the webbing does not, of course, pass over the handle of the screw.)

7. **Finochietto's tourniquet.** This is laid flat on the limb. The turns of stretched rubber tubing are forced down between the uprights, and the end, thickening when tension on it is relaxed, cannot slip back, and is thus secured.

8. ***Lynn-Thomas's tourniquet forceps.*** These forceps were found to be useful in military surgery, for arresting haemorrhage, and as a preliminary to high amputations of the thigh. One blade is probe shaped, while the other resembles a bowel clamp. The probe-blade is inserted through a small puncture wound and is passed deep to the femoral vessels, and the flat blade lies on the skin surface. When the blades are closed, the vessels are occluded.

Nos. 6 to 8 are illustrated on larger scale.



XX.—TOURNIQUETS

PLATE XXI

Raspatories or periosteal elevators are designed for raising the periosteum off a bone surface, and for stripping off muscular attachments.

Chisels, which are bevelled on one side only, are used for cutting or shaping bone for any purpose.

Osteotomes may be described as chisels of a special type, used for the operation of osteotomy, *i.e.* for *dividing* bone. Their edges are equally bevelled on both sides.

Gouges are used for cutting out a gutter or hollow in a bone, *e.g.* in the classical operation for osteomyelitis, or for drainage of the mastoid antrum.

✓1. **Faraboeuf's straight raspatory.**

✓2. **Faraboeuf's curved raspatory.**

3. ***Macewen's periosteal elevator.***

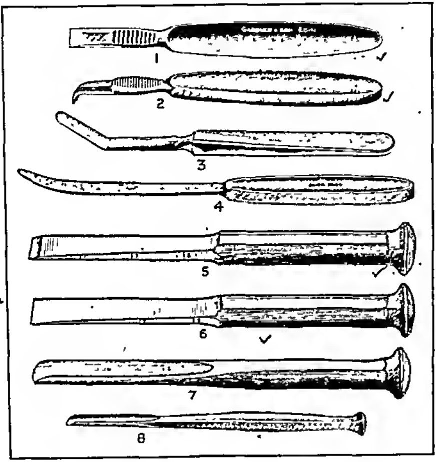
4. **Lane's periosteal elevator.**

✓ 5. **Chisel.**

✓ 6. **Osteotome.**

7. **Gouge.**

8. **Small gouge, suitable for mastoid operation.**



one side

Both sides Bevelled

XXI.—PERIOSTEAL ELEVATORS, CHISELS AND GOUGES

PLATE XXII

1. Fergusson's "lion-toothed" forceps.

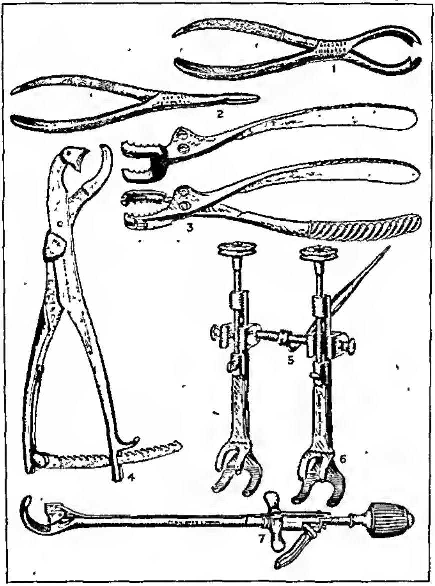
2. Lister's sequestrum or necrosis forceps. The blades are slender, so that they can be passed through a small opening in the outer bone.

3. Peters's bone-holding clamps. A choice of blades is available, and either of two joints may be used, so that both large and small bones may be gripped.

4. Lambotte's bone-holding forceps. Note the movable blade on the one side. This secures a much firmer grip.

5 & 6. Lowman's clamps with Coll's distractor. These clamps are used mainly for plating and bone-grafting operations. Each fragment is secured in a clamp and distraction is obtained by forcing the clamps apart, by means of the distraction apparatus.

7. Heitz-Boyer's clamp. This is very similar to Lambotte's clamp, but has a different mechanism for fixation.



XXII.—BONE-HOLDING FORCEPS AND CLAMPS

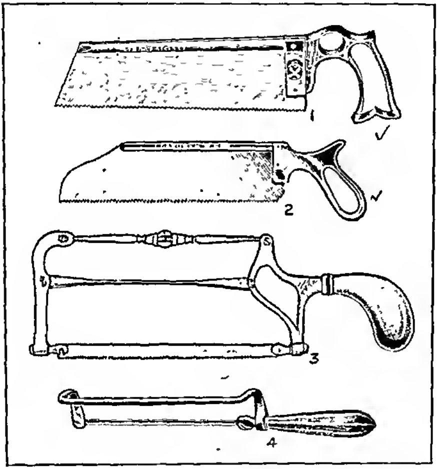
PLATE XXIII

1 & 2. Amputation saws.

3. Frame saw (Butcher's).

4. Merten's saw.*

* This saw was devised for the operation of excision of the knee joint. The narrow curved frame makes it possible for the bone ends to be sawn in a curved plane.



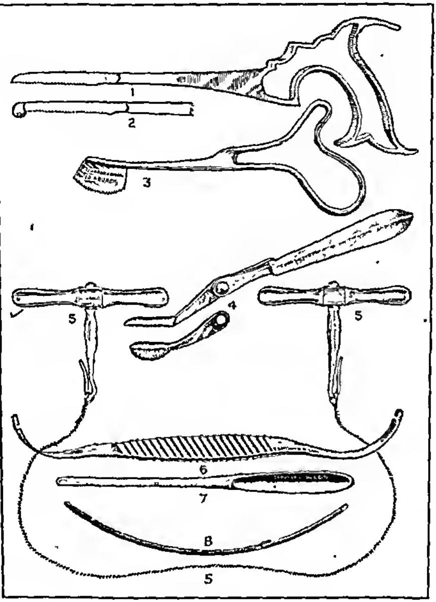
XXIII.—SAWS

PLATE XXIV

1. Adam's "key-hole" saw.*
2. Jones's "key-hole" saw.
3. Horsley's laminectomy saw.
4. Macewen's laminectomy saw and rasp.
5. Gigli's thread saw and handles.†
6. Stiles's Gigli saw introducer.
7. Cotterill's Gigli saw introducer.
8. Dott's (De Martels's) Gigli saw introducer.

* Designed originally for division of the neck of the femur.

† Used mainly for the cutting of an osteo-plastic flap in brain operations. It is passed by an introducer between trephine holes.



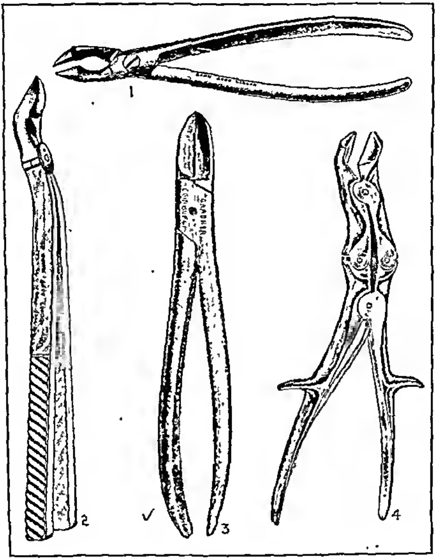
XXIV.—SAWS

PLATE XXV

1. & 2. Angled bone shears. *Laminectomy shears.*

3. Straight bone shears.

4. Double-action bone shears.

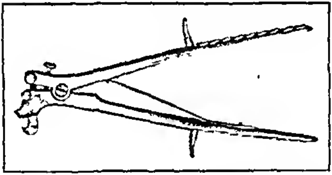


XXV.—BONE SHEARS LAMINECTOMY SHEARS

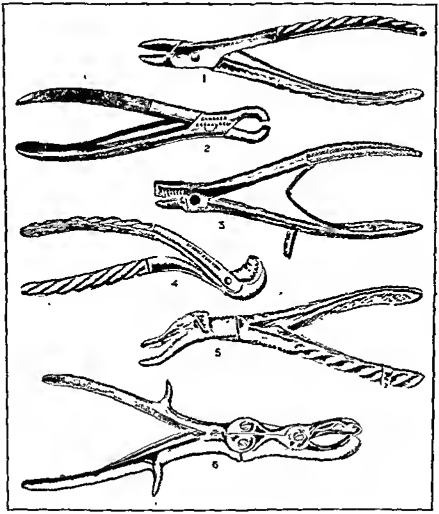
PLATE XXVI

Rongeur or nibbling forceps (gouge forceps) are designed mainly for enlarging a trephine hole in the skull, as in operations for decompression, but they can be used for removing or shaping bone for any purpose.

1. Lane's nibbling forceps.
2. Van Havre's gouge forceps.
3. Hoffman's nibbling forceps.
4. Lane's fulcrum forceps.
5. Jansen's nibbling forceps.
6. Double-action gouge forceps.



This instrument, which is designed on the same principle as plaster shears, is used to make a linear cut in the skull. The lower blade may be introduced through a small trephine hole.



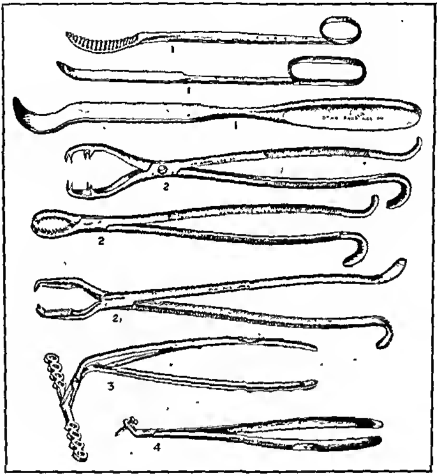
XXVI.—RONGEUR (NIBBLING) FORCEPS

De Viblis's Skull-Cutting Forceps

PLATE XXVII

This plate illustrates some of the instruments which were introduced by Arbuthnot Lane for the treatment of fractures. The fragments were exposed by open operation, and were held in alignment by means of steel plates fixed in position by machine screws. In an effort to minimize the risks of sepsis, the operation was carried out with a "no-touch technique"—hence the necessity for special instruments for holding plates, screws, etc.

1. Bone levers.
2. Bone-holding forceps.
3. Plate-holding forceps.
4. Screw-holding forceps.



XXVII.—LANE'S BONE INSTRUMENTS

PLATE XXVIII

Plates and screws made of beef bone have been substituted for steel plates in the treatment of fractures, and, in general, may be said to give better results.

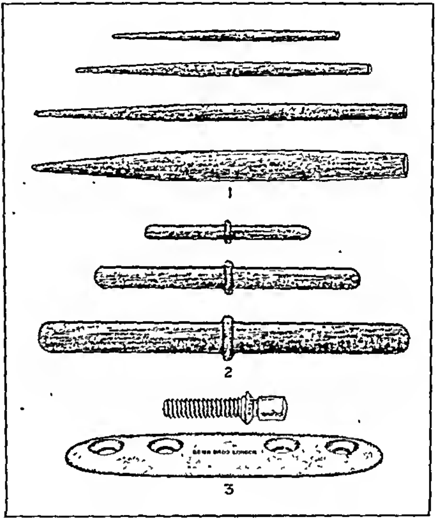
Plain pegs made of beef bone are useful for the fixation of fragments in position. A hole, the size of the peg, is first drilled in the bone; the peg is gently hammered in as far as may be thought necessary, and the excess is cut off.

Intra-medullary pegs are rounded at both ends and have a flange in the middle. They have been used in the treatment of transverse fractures, and are made in sizes suitable for the different bones. A hole of a size to suit the diameter of the peg selected is drilled up the medulla of each fragment. The fragments are then brought into end-to-end apposition over the peg.

1. Plain beef bone pegs.

2. Intra-medullary pegs.

3. Beef bone plate and screw.



XXVIII.—BEEF BONE PEGS, PLATES AND SCREWS

PLATE XXIX

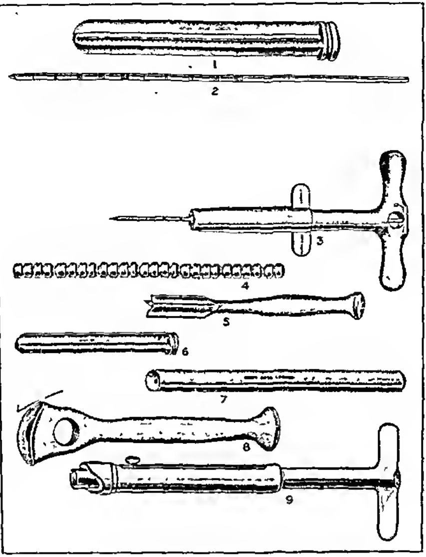
The nail designed by Smith Petersen for the treatment of fractures of the neck of the femur is three-flanged on cross-section. It is driven along the axis of the neck of the femur into the head, and secures fixation of the fragments in apposition. The flanges of the nail are so thin that there is the minimum of destruction to the spongy bone, and the fragments are prevented from rotating on one another, as they would be liable to do if a round nail were used.

Various modifications of this nail have been introduced, which allow the operation to be performed without the necessity of open exposure of the hip joint. The modern nails have a cannula up the middle, so that they can be "threaded" on a wire guide. This guide is inserted first into the bone, and its position confirmed by radiographs, before the nail is driven home.

Cross section of cannulated nail

Watson Jones's modification of the nail, together with the associated instruments, is shown here. (For a full description of the operation see pp. 116 to 125.)

1. **Cannulated Smith Petersen nail (Watson Jones's)** } *Larger scale.*
2. **Wire guide**—graduated in ½-inches or centimetres }
3. **Handle for inserting guide.**
4. **Measuring rod.** This is a plain rod which has a groove cut every quarter of an inch. It is laid alongside the femur, when the first radiograph after the insertion of the guide is being taken, and on the film it appears magnified to the same extent as the femur. The length of nail to be used may be determined, if the *apparent* length of nail required (as shown on the film) is measured against the *shadow* of the measuring rod; *e.g.* if the apparent length covers 13 grooves, a 3¼-in. nail is required.
5. **Tri-fin osteotome.** This can be used to make a tri-radiate cut in the cortex, prior to the insertion of the nail.
6. ***Nail** (in scale with other instruments).*
7. **Punch** by which the nail can be hammered in. It is cannulated, so that it can be used with the wire guide *in situ*.
8. **Impacting punch.** This fits over the head of the nail, and allows the hammer blows to be transmitted directly to the femur. By *its use the fragments are impacted over the nail, and any gap* which exists between them is closed.
9. **Broomhead's nail extractor.**



XXIX.—INSTRUMENTS FOR THE SMITH PETERSEN NAILING OPERATION
(Modified by Watson Jones)

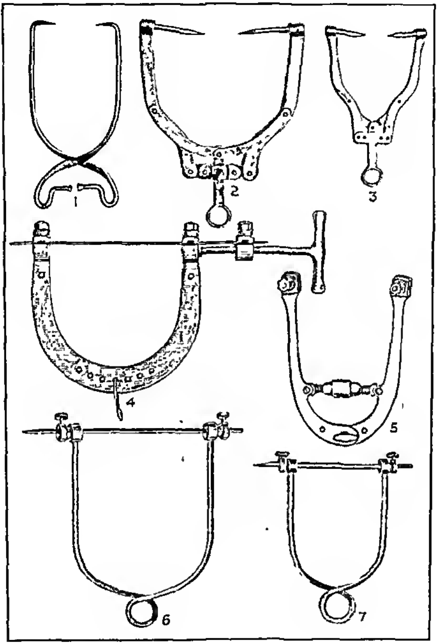
PLATE XXX

Skeletal traction is traction applied directly to bone. It is used mainly in the treatment of fractures.

The instruments used are of three main types. *Calipers* have sharp points which secure a firm hold by penetrating the cortical bone; they can only be applied to bony prominences, such as the condyles of the femur and the malleoli. *The Kirschner wire* is a fine wire of highly tempered steel, which is drilled through the bone: in order to make it taut, it is "stretched" in a special stirrup. *A pin with rotating stirrup* has been popularized by Böhler. The pin, 3 or 4 mm. in thickness, is drilled or hammered through the bone, and traction is applied through a stirrup, which can rotate freely on the pin. This rotation is essential as it prevents movements of the pin, which predispose to sepsis.

Skeletal traction is most commonly used in fractures of the femur. The different methods of its application are shown in Fig. 205. It is also employed to obtain traction on the lower leg, when it may be applied to the lower end of the tibia, to the malleoli, or to the calcaneum. For traction on the upper arm, a Kirschner wire may be passed through the olecranon, in line with the humerus. A special stirrup for use in such cases is shown in Fig. 95. Skull traction calipers are illustrated in Figs. 12 and 13.

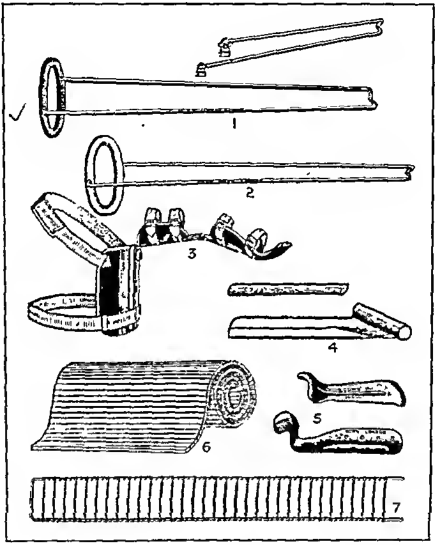
1. **Pearson's "ice-tong" calipers.**
2. **Böhler's calipers**—large size for condyles of femur.
3. **Böhler's calipers**—small pattern for application to malleoli, or to calcaneum.
4. **Kirschner wire apparatus**, consisting of a tempered steel wire, sharpened to a drill point at one end, stirrup, and "stretcher." The mode of action of the stretcher is apparent from the illustration. (The wire is not really stretched; the ends of the stirrup are approximated so that the wire is clamped under tension.)
5. **Schoemacher's stirrup**, for use with Kirschner wire.
6. **Böhler's pin with rotating stirrup.**
7. **Böhler's pin with rotating stirrup**—small size for calcaneum.



XXX.—INSTRUMENTS FOR SKELETAL TRACTION

PLATE XXXI

1. **Thomas's arm splint** is very similar to the well-known leg splint (Plate XXXII), but the padded ring is round, and it is placed at right angles to the side bars. The iron rod does not usually exceed ¼-inch in diameter. It is used in fractures of the arm, to steady the limb and to apply traction to it. Skin traction is usually employed, or, as an emergency measure, a clove-hitch may be passed *round* the wrist and tied to the end of the splint. It is best used in combination with a flexion-piece, which allows the elbow to be kept in the flexed position (Fig. 92).
2. **Sinclair's modification of Thomas's arm splint.** In this splint, the ring swivels on the side bars, so that traction can be applied with the arm at the side. It has a wide usefulness in military surgery, as it can be applied while the patient is being transported on a stretcher.
3. **Abduction ("aeroplane") splint.** Such splints are used in the treatment of fractures about the upper end of the humerus, where it is impossible to get apposition of the fragments with the arm at the side. They are also useful in cases where continuous traction has to be applied (Fig. 93), and in the treatment of weakness or paralysis of the abducting muscles. If complete immobilization of the shoulder joint or humerus is required, it is more satisfactory to employ an abduction plaster cast (pp. 86 and 87).
4. **Carr's wrist splint.** This consists of a plain wooden board 8 to 12 inches long, which has a piece of broom-stick attached to it obliquely at one end, and is hollowed out at one side to accommodate the thenar eminence. It is made for the right or left side. It may be used in conjunction with a small dorsal splint. It has been employed chiefly in the treatment of Colles's fracture; the method of its application in this condition is shown in Fig. 126.
5. **Jones's dorsi-flexion wrist splint** is used for maintaining the wrist in the dorsi-flexed position—as in the treatment of wrist-drop, tuberculous arthritis, sprains, etc.
6. **Gooch splinting** consists of strips of soft wood glued to a backing of canvas. When applied with the canvas side next the limb, it encircles the part as a ferrule; when applied with the wood against the skin, it does not bend. It can be cut to shape with a strong knife.
7. **Cramer's wire splinting.** This is made of aluminium alloy, and is light and strong. It can be used for fashioning various splints, especially abduction splints (Fig. 94). It is made in 3- and 4-inch widths for ordinary purposes, and in ¾-inch width for use as finger splints.



XXXI.—SPLINTS FOR THE UPPER EXTREMITY

PLATE XXXII

1. **Thomas's bed (knee) splint.** *The side bars of this splint are made of iron rod* ½- to ⅝-inch in diameter. At the upper end, the bars are welded to an ovoid ring of the same material, which is padded with felt and covered with firmly stretched leather. The ring is set obliquely at an angle of about 120 degrees to the side bars. It is unevenly piriform rather than oval in shape; the narrow part is placed laterally, and the flatter surface lies anteriorly. At the lower end of the splint, where the side bars are continuous with one another, there is a V-shaped notch to which traction tapes may be tied. Counter-pressure is provided by the padded ring which lies against the ischial tuberosity. The limb is supported by slings passed between the side bars.

   Originally designed for immobilization of the knee joint in cases of tuberculous arthritis, this splint has attained its greatest usefulness in the treatment of fractured femur (p. 178).

2. **Thomas's splint, with flexion-piece attached.** The flexion-piece hinges on the main splint, and is adjusted so that the hinge lies opposite the knee joint. This arrangement allows the knee to be flexed, and movements to be carried out, while the traction is maintained (Fig. 214).

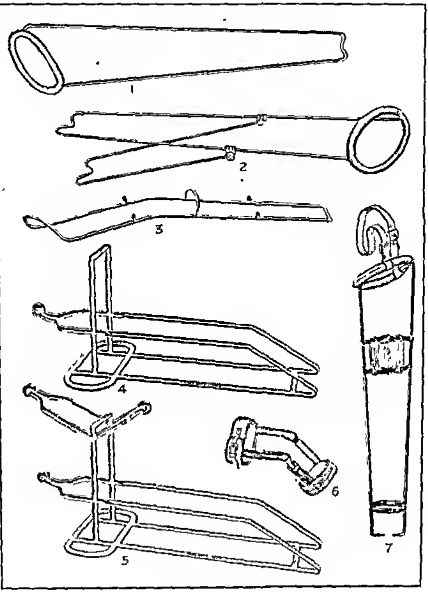
3. **Hodgen's splint,** This splint is somewhat similar to a Thomas's splint, but there is only "half a ring," and this is unpadded. In addition, two hooks are placed on each of the side bars. It provides no counter-pressure, but *merely acts as a cradle in which the limb is slung. Skin strapping applied* to the limb is tied to the end of the splint, and traction is exerted against the counter pull of the patient's own weight. A full description of the method is given on pages 182 to 184.

4. **Böhler's lower leg splint.** This is a particularly useful splint in the treatment of lower leg fractures. The knee is kept in a flexed position, and the elevation of the lower leg improves the circulation and reduces swelling. A pulley is provided so that traction can be applied in the line of the leg (pp. 215 to 217). When used in conjunction with an overhead frame, the splint may also be employed for the treatment of fractured femur (Fig. 221). *A wooden counterpart of this splint is illustrated in Figs. 257 to 260*

5. **Böhler's femur splint.** This is similar to the lower leg splint, but has two or three additional pulleys attached. One pulley is always placed in line with the inclined plane for traction on the femur, and a second pulley (not shown here) may be fitted for traction in a line nearer to the horizontal, as in the case of supra-condylar fractures. The most proximally placed pulley provides for dorsi-flexion of the foot (Fig. 222).

6. **"Knee cage."** This consists of two collateral bands of metal hinged opposite the knee joint. They are secured to the limb by two stout leather cuffs, reinforced with metal, which encircle the thigh and calf. Used in the treatment of injuries to the ligaments and cartilages of the knee joint, the knee cage allows a fairly full range of movement in flexion and extension, but prevents lateral movement, and rotational strains (Fig. 249).

7. **Thomas's walking caliper splint.** This is similar to the bed splint, but at the lower end the side rods are turned in at right angles to fit into the ends of a tube passed through the heel of the patient's boot. When the splint is worn, the limb is relieved of weight-bearing, as the pressure is transmitted directly to the ischial tuberosity through the padded ring. The splint must be made accurately to fit each patient, and the length should be adjusted so that the under surface of the patient's heel is clear of the boot (Fig. 196).



XXXII.—SPLINTS FOR THE LOWER EXTREMITY

PLATE XXXIII

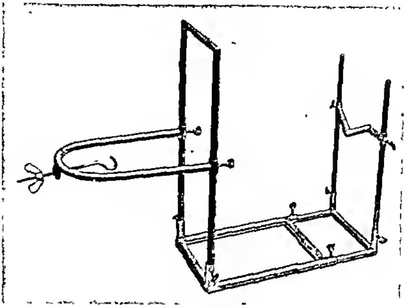
Böhler's screw traction apparatus consists of an extensible frame on which two pairs of uprights are placed. On the proximal pair of uprights, there is a transverse bar, the height of which can be adjusted. The knee is flexed over this bar, which is specially shaped, to allow for the more distal insertion of the hamstring tendons on the medial side. (The transverse bar is therefore placed with opposite sides uppermost, in the case of right- and left-sided fractures.) On the distal pair of uprights, which are joined at the top, is placed a horizontal hoop, also adjustable in height. This carries a hook, on which traction can be applied by turning a winged nut.

Method of use (see also p. 219). Skeletal traction is applied—usually to the calcaneum. The bar and hoop are adjusted equally at a height suitable for the individual case. The knee is flexed over the bar; the traction appliance is attached to the hook, and traction is obtained by turning the screw. By this method adequate traction is obtained, while the leg is left entirely free for the application of plaster. *The use of a traction indicator is essential* (Fig. 231).

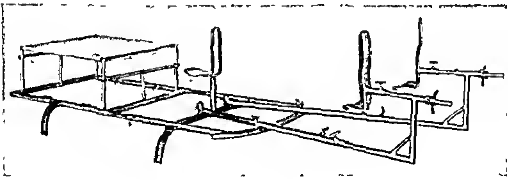
PLATE XXXIV

Author's portable traction table. This consists of two frames of tubular steel which telescope one into the other. The one frame has a collapsible canvas "stool" for supporting the head and shoulders, and is adjustable in relation to the other frame which bears the pelvic rest. This is of a design which enables the counter-pressure to be taken by two uprights against the ischial tuberosities or sacro-tuberous ligaments. The horizontal part of the pelvic rest is shaped to fit the curve of the sacrum, so that it does not interfere with accurate moulding of a plaster cast. The traction rods or leg pieces, also of telescopic tubing, pivot round axes corresponding in position to the hip joints, and can be fixed in any degree of abduction, by means of a thumb screw. The foot pieces, which are moulded to fit the foot, have an extension round the back of the heel, providing a socket in which the heel lies snugly. A few turns of bandage secure firm fixation of the foot at a right angle, and slipping of the bandage is prevented by the hook shape of the heel piece. The foot pieces are mounted at the ends of traction screws, and are adjustable in any degree of rotation. Traction is obtained by means of a large wing nut which turns on the screw.

The portable traction table is used to obtain traction on the lower limbs, in any position of abduction and rotation. At the same time, the trunk and limbs are left free for the application of a plaster cast. The apparatus may be used in the Smith Petersen nailing operation (Fig. 189), the reduction of basal fractures of the neck of the femur (Fig. 198) and numerous other conditions (Figs. 182, 229, and 230)



XXXIII.—BOHLER'S SCREW TRACTION APPARATUS



XXXIV.—AUTHOR'S PORTABLE TRACTION TABLE

(Illustration kindly lent by the Medical Supply Association.)

PLATE XXXV

1. **Parham's band.**
2. **Introducer.**
3. **Tightener.**

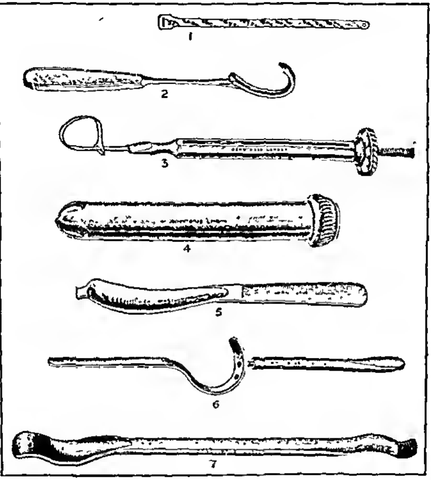
Parham's band, which may be used in the treatment of oblique fractures, consists of a steel spring, shaped and slotted as shown in the illustration. The band is passed round the fragments, and threaded upon itself to form a noose, which is tightened by means of the special instrument. It is then bent acutely over at the "knot," hammered down, and the excess cut away. By this means the fragments can be held in firm apposition.

4. **Doyen's rongeur**—devised for gouging out the acetabulum, in open operations for congenital dislocation of the hip.

5. **Kocher's hip lever**—used for levering the head of the femur into position, in operations on the hip joint.

6. **Hey Groves's bone lever.** This is used to keep bone fragments elevated in a wound. The amount of elevation can be varied according to the hole into which the right-hand part is screwed.

7. **Murphy's "skid" or bone lever**—devised for operations on the *hip joint*.



XXXV.—MISCELLANEOUS BONE INSTRUMENTS

PLATE XXXVI

1. Fergusson's metatarsal saw.

2. Langenbeck's saw.

3. Hey's skull saw.

4. Bone awl—used for boring holes by hand. The point has an eye, through which wire or other suture material may be threaded and drawn back.

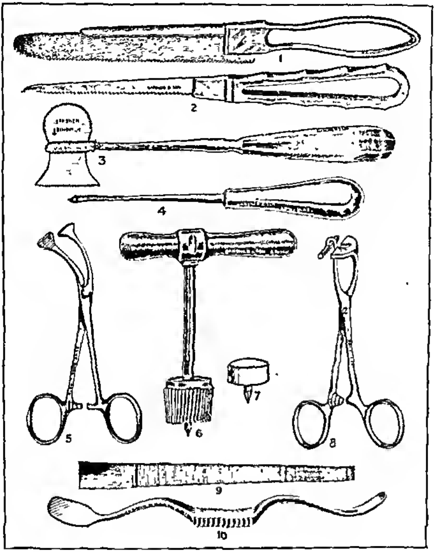
5. Sargent's scalp forceps 8. Fraser's scalp forceps	These are used in brain operations, to arrest haemorrhage from the scalp incision. Several pairs are placed side by side along the cut edges.

6. Horsley's skull trephine. By its use, a circular disc of bone is removed. (Pin shown in position.)

7. Pin for use with trephine. This pin, which is mounted on a small disc, fits inside the trephine, so that its point projects by about $\frac{1}{8}$-inch. It provides a centre around which the surgeon can describe a circle with the cutting edge. When the circular cut is sufficiently established, the pin is removed.

9. Elevator for raising trephine disc of bone: the broad end is a segment of a circle.

10. Horsley's dura mater separator and skull elevator.



XXXVI.—MISCELLANEOUS BONE INSTRUMENTS
SCALP FORCEPS

PLATE XXXVII

1. **Thomas's wrench**—used for forcible manipulation of bones and joints, particularly in the case of foot deformities (Figs. 297, 308, 309, and 312).

2. **Tubby's modification of Thomas's wrench.** The fixed blade is curved, so that the wrench is less likely to slip during the manipulation.

3. **Böhler's redresseur**—used for obtaining side-to-side compression of the calcaneum, when the bone is broadened as the result of fracture (Figs. 290 and 291). With "pads" of different shapes, it can also be used in the treatment of fractures of the tibial condyles.

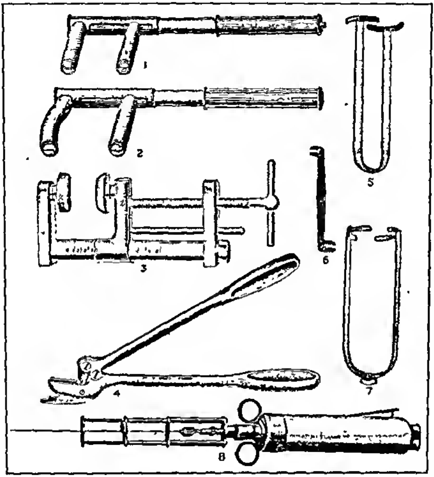
4. **Lorenz's plaster shears**—used for the removal of plaster casts.

5. **Böhler's walking iron**—for incorporation in a plaster cast. It projects 2 to 2½ inches beyond the heel of the cast. Weight is then transmitted to the cast as a whole, and the sole-piece of the cast is protected from contact with the ground (pp. 234 to 240).

6. **Lane's bone plate bender**—may be used for shaping the walking iron so that it fits round the malleoli (Fig. 280). A much neater cast will result, and additional weight will be saved.

7. **Walking iron fitted with rubber heel.** The heel gives the patient greater confidence in walking, and is less destructive to carpets and linoleum.

8. **Electric drill for insertion of Kirschner wire.** This is fitted with a telescopic extension, which keeps the wire straight before it enters the bone (Fig. 207).

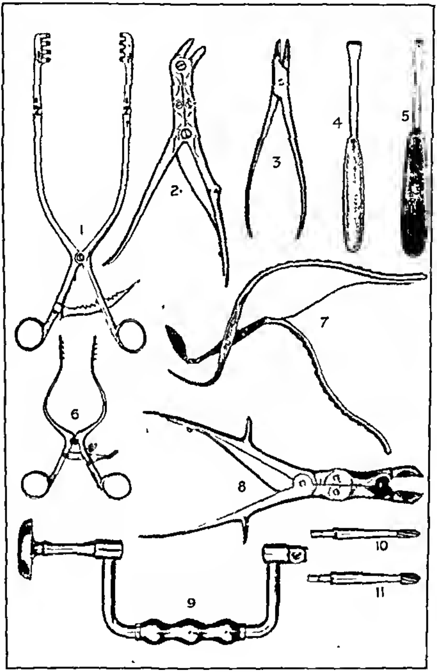


XXXVII.—ORTHOPAEDIC AND FRACTURE APPLIANCES

PLATE XXXVIII

1. **Mayo's goitre retractor.**—A useful retractor for spinal and cerebellar exposures.
2. **Double-action gouge forceps.**
3. **Stille's gouge forceps.**
4. **Blunt periosteal elevator.**
5. **Sharp periosteal elevator.**
6. **Mollison's mastoid retractor.**—Also useful in spinal and cerebellar work.
7. **Fraser's laminotomy shears.**—The slender blade can be insinuated deep to the lamina, without injuring the cord.
8. **Double-action laminectomy shears.**

9., 10., 11. **Hudson's brace, with small and large burrs.**



XXXVIII.—INSTRUMENTS FOR OPERATIONS ON THE BRAIN AND SPINAL CORD

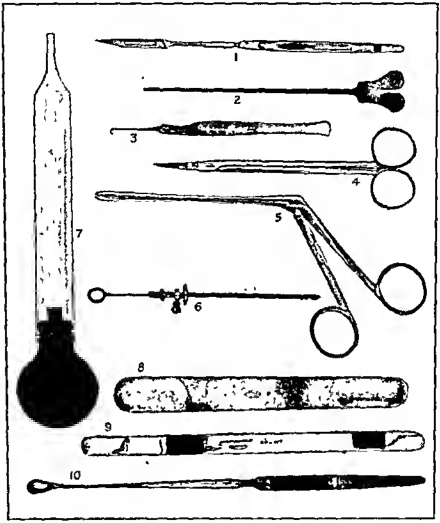
(With the co-operation of Mr. Norman Dott)

PLATE XXXIX

1. **Bard-Parker handle** (*No.* 7), **with blade** (*No.* 11).
2. **Grooved director.** Used mainly for incision of the dura. The tip is curved, so that it can be directed easily in the plane between dura and arachnoid.
3. **Dural hook.** For picking up and steadying dura prior to incision. It can also be used for lifting up small vessels for ligature or cauterization.
4. **Dott's scissors.** The long handles and short blades are required for working at a depth in a confined space.
5. **Pituitary rongeur.** Employed for excavating and removing fragments of tumour in any situation. Used gently, it makes a good vulsellum for a cyst wall.
6. **Blunt exploring needle.** This is 10 cm. long, and is graduated from the tip. The stylet fits loosely and drops into position without friction. The flange is adjustable by means of a pinch-screw; it bears against the dura or cerebral surface, and prevents penetration beyond the desired depth.
7. **Glass irrigator.** For flushing brain surface and cavities.

8 & 9. **Brain spoons.**

10. **Pituitary spoon.** Made of soft copper, it can be bent easily, and is therefore adaptable to any particular difficulty of access.



XXXIX.—INSTRUMENTS FOR OPERATIONS ON THE BRAIN AND SPINAL CORD

(With the co-operation of Mr. Norman Dott)

PLATE XL

1. **Gum-elastic* oesophageal bougies.**
2. **Chiene's oesophageal bougie,** consisting of a long whalebone handle to which olive-shaped metal tips of graduated sizes are attached.

Oesophageal bougies are used for the gradual dilatation of fibrous strictures, or for the alleviation of cardiospasm. For this latter condition, a rubber tube, closed at its end, and filled with mercury (Hurst's bougie), has been found to be most useful.

3. **Bristle ("umbrella") probang†**—formerly used for the extraction of fish bones and other light foreign bodies. It was passed down the oesophagus in the "closed" state, as illustrated. Before it was extracted, a pull on the handle brought the ends of the bristles closer together, so that a spindle was formed, like an opened umbrella.

4. **Coin-catcher.†** An ingenious instrument designed for the extraction of coins impacted in the oesophagus. It was passed beyond the coin, and as it was withdrawn the coin was caught up in the specially shaped socket at its end.

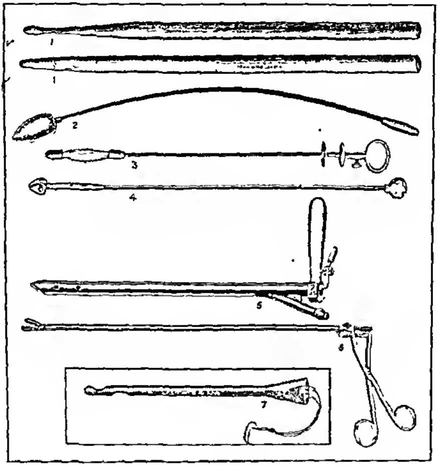
5. **Oesophagoscope.** This is a tube about 18 inches long and ½-inch in diameter, which carries a light at its extremity. At the handle end, to which the necessary electrical connection is made, there is attached also a small side tube through which mucus or blood may be aspirated. It is used for diagnostic purposes *e.g.* for examining the mucosa of the oesophagus and the cardiac sphincter, and for the removal of foreign bodies.

6. **Oesophageal forceps**—for use with oesophagoscope. They can be employed for swabbing away mucus, for the extraction of foreign bodies, or for the removal of tissue for histological examination.

7. **Symond's tube** (*illustrated in larger scale*). This is a gum-elastic* tube, 6 to 8 inches long, with two lateral openings near the tip, and funnel-shaped at its upper end. It has been used chiefly in cases of fibrous stricture, as a method of producing gradual dilatation, but has also been employed in malignant disease to enable fluids to be swallowed. It is inserted by a special introducer, and is impacted in the stricture. Attached to it is a stout silk thread which hangs out of the mouth. This enables the tube to be changed at intervals.

* "*Gum-elastic*" is a material composed of woven silk or cotton impregnated with gum resins. It is flexible but resilient. As a rule, gum-elastic instruments cannot be sterilized by boiling, but recently certain brands have been put on the market, which can be boiled for a short time.

† These instruments are now only of historical interest, as they have been entirely replaced by the oesophagoscope.



XI.—OESOPHAGEAL INSTRUMENTS

PLATE XLI

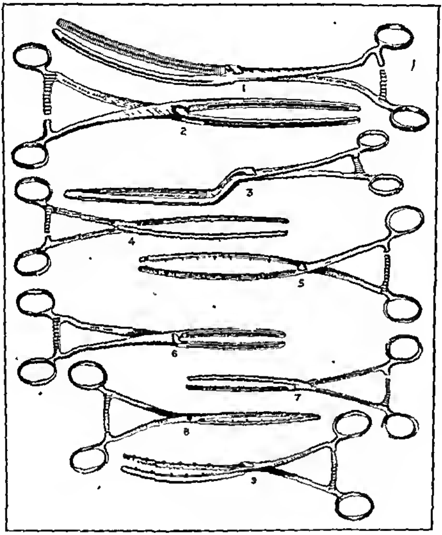
Occlusion clamps for the stomach and intestine are used in operations where the viscus is being opened for any purpose, or when a portion is being resected. They serve to steady the viscus, to prevent escape of content, and to prevent haemorrhage.

The blades of such clamps may be covered with rubber tubing. This diminishes the likelihood of injury to the viscera.

1. Moynihan's* stomach clamp—curved.
2. Moynihan's* stomach clamp—straight.
3. Moynihan's* clamp with cranked bend.
4. Doyen's stomach clamp.
5. Payr's† stomach clamp.
6. Moynihan's* intestinal clamp.
7. Kocher's intestinal clamp.
8. Payr's† intestinal clamp—straight.
9. Payr's† intestinal clamp—curved.

* Note fenestrated blades. This makes for lightness and increased *elasticity*.

† Note that the blades have blunt hooks along one edge, to prevent slipping of the viscus. These clamps take a very light grip, so that the protection of rubber tubing is unnecessary.



XLI.—GASTRIC AND INTESTINAL OCCLUSION CLAMPS

PLATE XLII

Gastro-enterostomy clamps are essentially three-bladed clamps or twin clamps. They serve three purposes—to hold the stomach and jejunum in contact during the performance of the anastomosis, to prevent escape of content, and to prevent haemorrhage. Suggested objections to their use are that they may injure the visceral walls, and that they may mask haemorrhage, which may occur after their removal. They have been blamed for the causation of pressure ulceration.

1. **Moynihan's gastro-enterostomy clamp** is an example of the three-bladed type. The blades are fenestrated for tightness and greater elasticity.

2. **Lane's gastro-enterostomy clamp** consists of two twin clamps each of which has one straight side, so that they can be locked together with their ends pointing in the same or in opposite directions. They may be straight or slightly curved.

3. **Wilkie's duodeno-jejunostomy clamp** has cranked blades which can sink more deeply into the wound, causing less traction on the viscera. It has been used for gastro-enterostomy, but the blades are rather small for this purpose.

4. **Dott's gastro-enterostomy clamp** has the advantage of compactness. The two halves of the clamp are hinged at one end. Fixation of the blades is obtained by thumb nuts; these are rapidly adjusted, as they slide up the screws and only engage with the thread when tension is taken up.

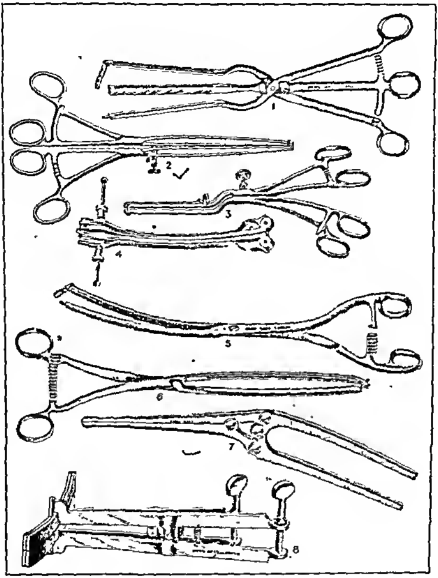
Gastrectomy clamps are used to clamp the stomach proximal to the part which is to be excised; the division is usually made between two pairs of such clamps.

5. **Kocher's gastrectomy clamp.**

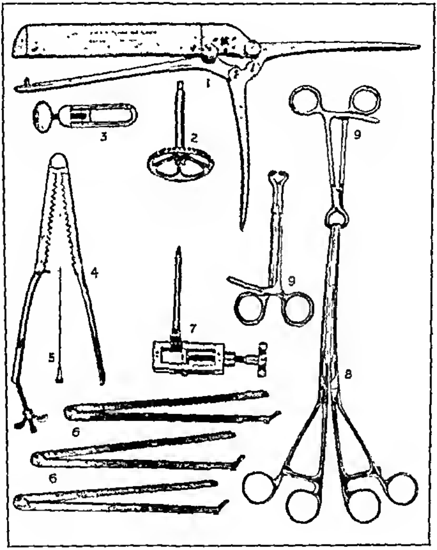
6. **London Hospital gastrectomy clamp** is of the occlusive or controlling type; it will produce the minimum of injury to the stomach wall, and is suitable for the type of operation (Polya) where the whole or part of the cut end of the stomach is to be anastomosed with the jejunum.

7. **Payr's gastrectomy clamp** is of the crushing type, and by its double action produces extreme crushing of the stomach wall. It is employed in the type of operation (Billroth II) where the cut end of the stomach is completely closed, and continuity is established by a gastro-jejunostomy. The crushing, which leaves the serous coat intact, greatly facilitates the closure.

8. **Schoemacher's gastrectomy clamp** is modelled on an attempt to preserve as far as possible the normal shape of the stomach, and is only suitable for use in a modified gastrectomy performed for ulceration. A relatively small segment of stomach is resected, and the remainder is anastomosed to the duodenum.



XLII.—GASTRO-ENTEROSTOMY AND GASTRECTOMY CLAMPS.



XLIII.—GASTRO-ENTEROSTOMY AND GASTRECTOMY CLAMPS SUTURING CLAMPS

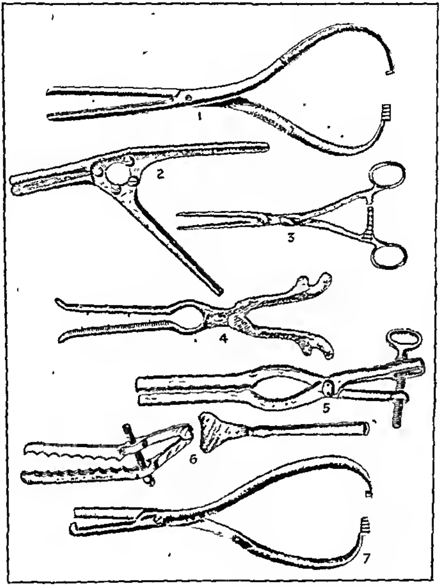
PLATE XLIV

Intestinal crushing clamps are used in operations for resection of a segment of bowel. Such clamps are usually employed where the cut end of the bowel is to be closed either by suture or by simple ligature, and continuity is to be re-established by lateral anastomosis.

All such clamps may be referred to as *enterotribes* or *enterotomes*, but these terms are more commonly employed to denote special clamps designed for crushing the spur between adjacent loops of bowel, as in the Mikulicz operation. The essential feature of these latter clamps is that they crush slowly; the segment of spur between the blades gradually sloughs away, and continuity between the two loops is established, without endangering the peritoneal cavity to infection.

Appendix clamps can be used to crush a groove at the base of the appendix preparatory to ligation. Artery forceps are equally efficient.

1. **Wade's intestinal crushing clamp.**
2. **Payr's intestinal crushing clamp.**
3. **Schoemacher's colectomy clamp.** The blades are slender so that it can be used for "aseptic anastomosis." The cut ends of bowel, each occluded by a clamp, are joined together by an encircling sero-muscular suture. When this is completed, the clamps are removed.
4. **Mikulicz's enterotribe.** It is tightened by means of stretched rubber tubing or by an elastic band passed round the handles.
5. **Dupuytren's enterotribe**—tightened by a winged screw.
6. **Hey Groves's enterotribe**—tightened by a "watch key."
7. **Coroer's appendix clamp.** This crushes a broad groove in the appendix. Its rounded end prevents the possibility of injury to the caecum.



XLIV.—INTESTINAL CRUSHING CLAMPS
ENTEROTRIBES APPENDIX CLAMP

PLATE XLV

1. **Pile forceps**—used for grasping the pile mass.

2. **Pile forceps**—used for clamping the base or pedicle of the pile, preparatory to ligation or over-stitching. The blades should be serrated longitudinally; a firmer grip is then secured, and the clamp slips out more easily when the running suture is in position.

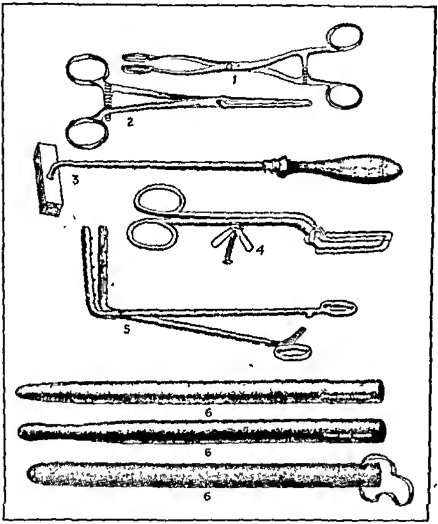
3. **Pile cautery.** This is used to burn away the pile masses. When applied to the pile, the cautery should be at a black heat. (If it is red-hot it will burn away the tissue too quickly and haemorrhage will not be arrested.) It is used in conjunction with the special clamp illustrated below.

4. **Clamp for use with cautery (Smith's).** The blades are guarded by ivory plates, which protect the skin from burning. (A wet towel is used as additional protection.) The clamp must always be applied *radially* to the anal orifice. An external and an internal pile may therefore be clamped at the one time.

5. **Fraser's clamp for perineal excision of rectum.** The bowel may be divided between two pairs of such clamps. The hooks on the blades are relatively sharp (*cf.* Payr's intestinal clamps), as a firm hold is essential, and any slight injury they may inflict on the bowel is in this case immaterial.

6. **Gum-elastic* rectal bougies.** Graduated sizes are available in the different shapes illustrated. They are used for dilatation of simple strictures.

* See footnote (*) Plate XL.



XLV.—INSTRUMENTS FOR OPERATIONS ON RECTUM AND ANAL CANAL

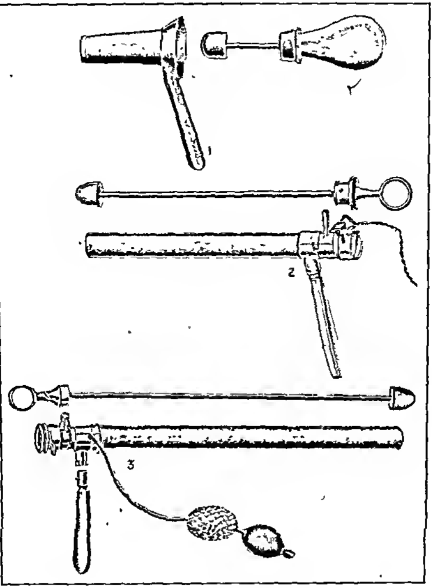
PLATE XLVI

1. **Anal speculum**—used for inspection of the mucosa of the anal canal, and for the injection treatment of piles.

2. **Proctoscope.** This is about 8 inches long and ⅞-inch in diameter. After insertion of the instrument, the obturator is withdrawn, and is replaced by a long slender rod bearing a lamp at its end. The external end of the tube is closed by means of a plain glass lens.

3. **Sigmoidoscope.** This is of the same calibre as the proctoscope, but is about 12 inches long. It is fitted in addition with a small side tube, through which air may be pumped by means of a rubber bulb. This balloons out the bowel beyond the instrument, and facilitates inspection of the mucosa; it may also permit of the instrument being passed to a greater distance under direct vision.

The proctoscope and sigmoidoscope are used in conjunction with long forceps, similar to that shown with the oesophagoscope (Plate XL). With such forceps, swabbing can be carried out, or tissue removed for histological examination.



XLVI.—INTESTINAL SPECULA

PLATE XLVII

1. **Gall bladder trocar and cannula (Ochsner's).** The side tube, to which rubber tubing is attached, allows infected bile to be drained away without risk of soiling the peritoneal cavity.

2. **Gall stone scoop**—for the removal of stones from the gall bladder.

3. **Mayo's gall stone spoon or "tray."** This is held alongside the *opening into the gall bladder, while stones and* biliary mud are scooped into it.

4. **Moynihan's cholecystectomy forceps.**
5. ***Gray's cholecystectomy forceps.***

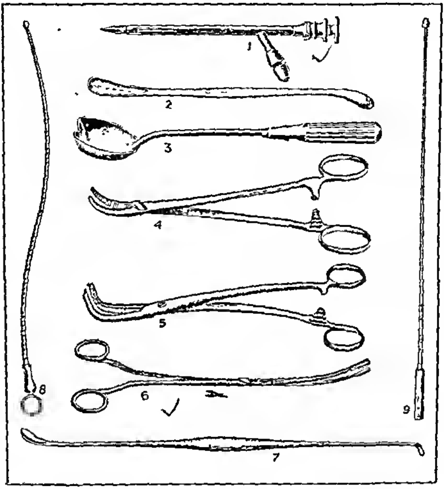
Used for clamping the cystic duct, and cystic artery, in the operation for removal of the gall bladder.

6. **Désjardin's duct forceps**—used for the removal of stones from the ducts.

7. **Cheatle's hook and scoop**—used for the freeing and extraction of stones impacted in the ducts.

8. **Mayo's common duct probe.**
9. **Désjardin's common duct probe.**

For investigating the patency of the duct.



XLVII.—INSTRUMENTS FOR OPERATIONS ON GALL BLADDER AND BILE DUCTS

PLATE XLVIII

Urethral catheters are hollow tubes used for evacuation of urine from the bladder. They may be made of plain rubber, of gum-elastic,* or of metal.

Catheters are calibrated according to two scales, on which the outside diameter of the catheter is represented. On the English scale the unit is taken as $\frac{1}{2}$ mm., while on the French scale (*Charrière*) it is $\frac{1}{3}$ mm. *The* largest *urethral* catheter which is commonly used, and which should pass through the normal urethra, has an outside diameter of 7 mm.; this corresponds on the English scale to 12, and on the French scale to 21. The urethral catheters generally available range from 3 to 12 (English), or from 8 to 21 (French).

1. **Plain rubber catheter.**
2. **Dowse's self-retaining catheter.**
3. **Pousson's self-retaining catheter.**

Self-retaining urethral catheters are now seldom used, as they are difficult to remove, and the tip is liable to become broken off in the bladder. They are straightened out or stretched by means of a stiff wire stilette before insertion.

4. **Gum-elastic catheters—straight.**
5. **Gum-elastic catheter—coudé.**
6. **Gum-elastic catheter—bicoudé.**

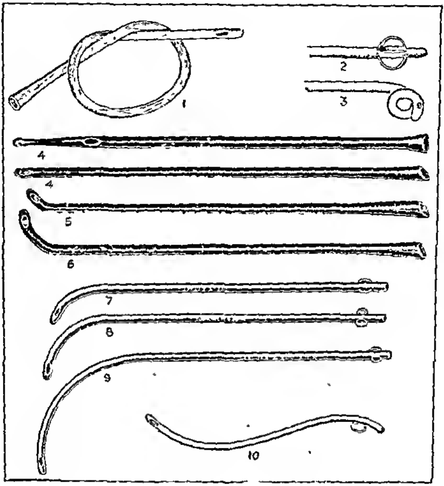
The coudé and bicoudé catheters are for use in cases of prostatic hypertrophy, as the bend facilitates the passage of the instrument past the enlarged "middle lobe" of the gland.

7. **Chiene's metal catheter.**
8. **Syme's metal catheter.**

Metal catheters are usually fitted with two wire loops at the external end, so that they can be tied in if desired.

9. **Metal catheter for prostatic cases.** These catheters have a much larger curve, to suit the elongation and abnormal curvature of the prostatic urethra, produced by the glandular hypertrophy.
10. **Female metal catheter.** Female catheters are also made of glass. *The tube may be straight or slightly bent.*

* See footnote (*) to Plate XL.



XLVIII.—URETHRAL CATHETERS

PLATE XLIX

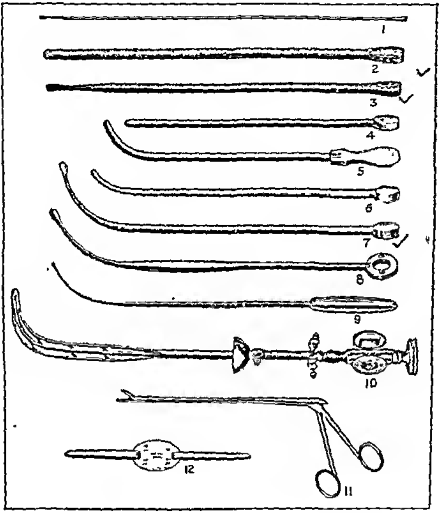
Urethral bougies are solid instruments employed for the gradual dilatation of fibrous strictures. In general they taper slightly towards the point, but some patterns have a bulbous end, or an expansion in the middle of the blade. They may be made of metal, of gum elastic,* or of *whalebone*.

1. **Whalebone (filiform) bougie.** Such bougies have been employed ✓ with success in the treatment of retention of urine due to stricture. Two or more bougies may be passed beyond the stricture, and the urine may then be allowed to dribble away alongside, or, after their withdrawal, it may be possible to pass a catheter.
2. **Gum elastic bougie—cylindrical.**
3. ***Gum elastic bougie—bulbous tip.***
4. **Anterior urethral bougie.**
5. **Clutton's bougie.**
6. **Chiene's bougie.**
7. ✓ **Lister's bougie.**
8. **Nicoll's bougie.**

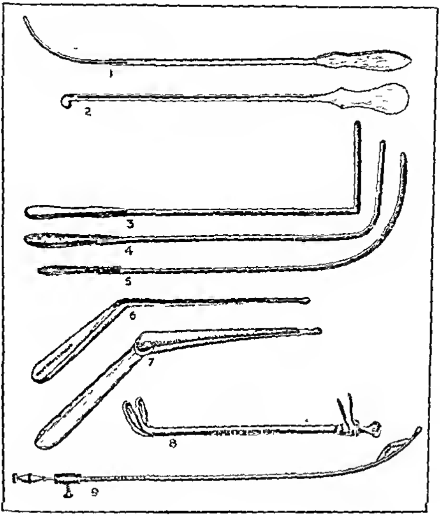
(4–8) Each of these metal bougies is available as a series of instruments of graduated thickness. Numbers stamped on the handle indicate, on the English catheter scale, the diameter of the different parts of the instrument.

9. **Miller's bougie.** This *bougie is made in one size only. It is* markedly tapered, and the point is only slightly bulbous. It should be made to pass *by its own weight alone*—hence the heavy handle.
10. **Kollmann's dilator.** The *blade consists of four wires, which are* forced apart by means of a screw at the handle. The amount of dilatation is read off on a scale. It is used for the dilatation of soft or recent strictures, and is popular with venereologists.
11. ***Urethral forceps*—*used for the extraction of foreign bodies from* the urethra.**
12. **Mealal dilator.**

* See footnote (*) to Plate XL.



XLIX.—URETHRAL BOUGIES AND DILATOR
URETHRAL FORCEPS



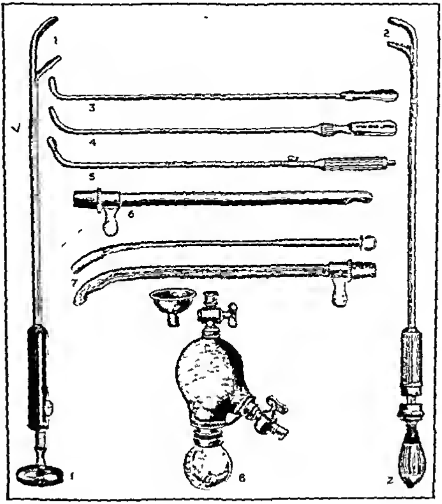
L.—INSTRUMENTS FOR PERINEAL OPERATIONS
INTERNAL URETHROTOME

PLATE LI

Bladder sounds have some resemblance to bougies, but they do not increase in thickness towards the handle, they are angled more acutely, and have a shorter beak, to permit easy rotation in the bladder. They were used in the classical operation of "sounding for stone." The elicitation of a clinking sensation was positive evidence of the existence of a vesical calculus. This method of examination has now been replaced by cystoscopy.

In the operation of lithotrity, vesical stones are crushed in situ by special instruments known as *lithotrites* or *lithotribes*, which are introduced per urethram. The crushing is repeated until all fragments are reduced to as small a size as possible. They are then evacuated through a large bore catheter. The evacuation is assisted by a special apparatus (*evacuator*), which enables a stream of water to be alternately pumped into, and sucked out of the bladder by means of a rubber bulb. As the crushed fragments pass out with the stream, they fall down to the glass bulb in the lower part of the apparatus.

1. Thompson's lithotrite.
2. Bigelow's lithotrite.
3. Mercier's sound.
4. Thompson's sound.
5. Flushing sound.
6. Evacuating catheter – straight.
7. Evacuating catheter – curved.
8. Bigelow's evacuator.

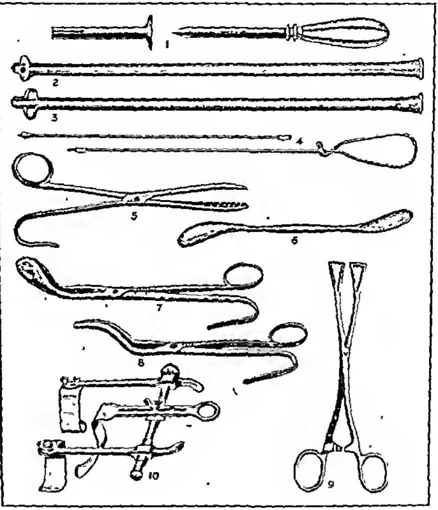


LI.—BLADDER SOUNDS LITHOTRITY INSTRUMENTS

PLATE LII

1. **Cautlie's trocar and cannula.** Originally designed for aspiration of liver abscesses, this instrument is now used mainly in the operation of supra-pubic cystostomy. It may be passed through the bladder wall alone, after this has been exposed by open operation, or in the "blind" method it may be stabbed in addition through the linea alba of the abdominal wall, after a small incision has been made in the skin. The cannula has an external diameter of 10-12 mm. (English catheter gauge*—18 to 22).

2. **de Pezzer's self-retaining supra-pubic catheter.** 3. **Malecot's self-retaining supra-pubic catheter.**	These catheters may be passed through the Cautlie's cannula. They are stretched on the wire stretcher, and are lubricated before insertion. The catheters in common use are calibrated 18 to 24 on the English scale.*



LII.—INSTRUMENTS FOR OPERATIONS ON THE BLADDER

PLATE LIII

1. Wade's nephrectomy forceps.*

2. Thomson Walker's nephrectomy forceps.*

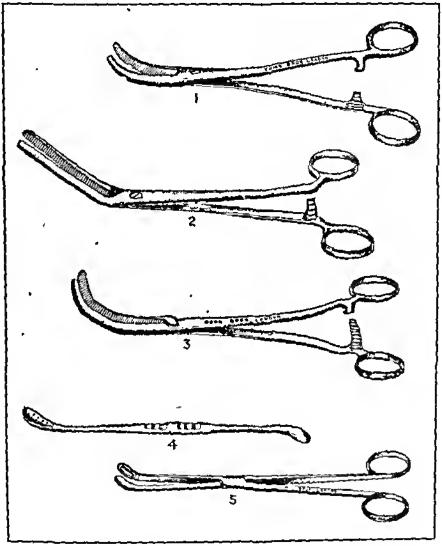
3. Bicoudé nephrectomy forceps.*

4. Pyelo- or nephro-lithotomy scoop.†

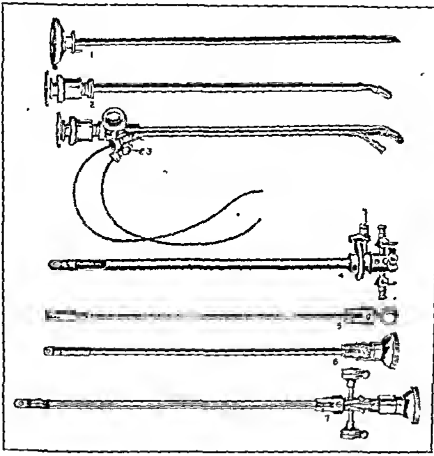
5. Pyelo- or nephro-lithotomy forceps.†

* Used for clamping the renal pedicle in the operation for removal of the kidney.

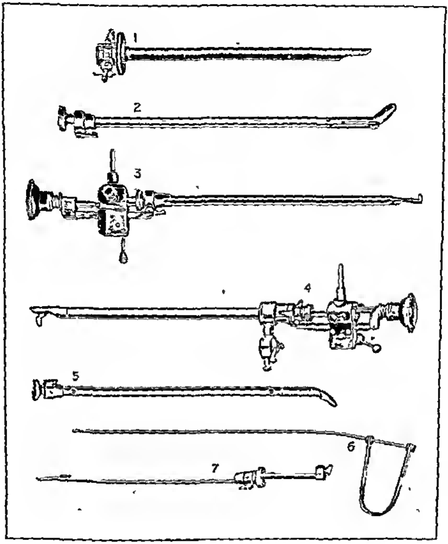
† For removal of stones from the kidney.



LIII.—INSTRUMENTS FOR OPERATIONS ON THE KIDNEY



LIV.—CYSTOSCOPES

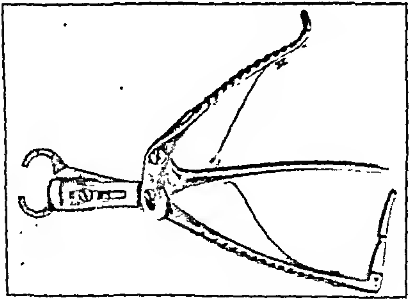


LV.—McCARTHY'S PROSTATIC ELECTROTOME
("RESECTOSCOPE")

(Material for illustration kindly provided by the Genito-Urinary Mfg. Co. Ltd., London.)

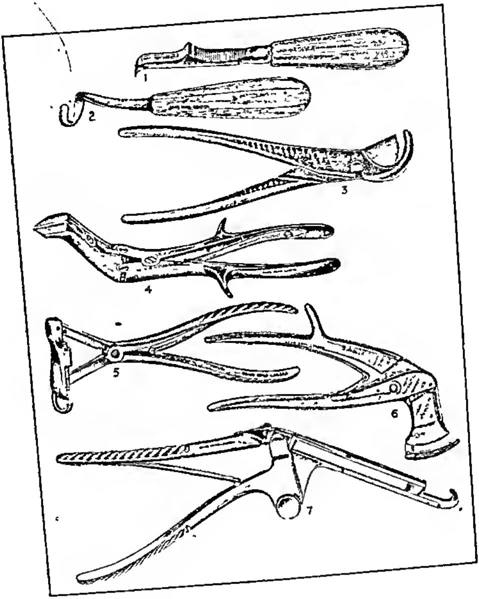
PLATE LVI

1. Nelson's rib raspatory.
2. Doyen's raspatory (" rib stripper ").*
3. Estlander's rib shears.
4. Tudor Edwards's rib shears.
5. Schoemacher's rib shears.
6. Exener's rib shears.
7. Sauerbruch's 1st rib shears.

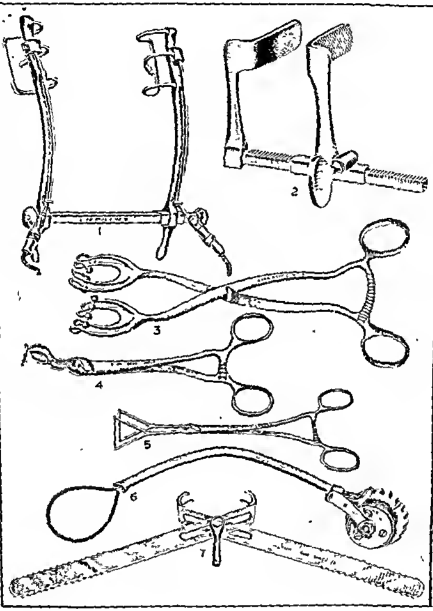


Morriston-Davies's rib shears.

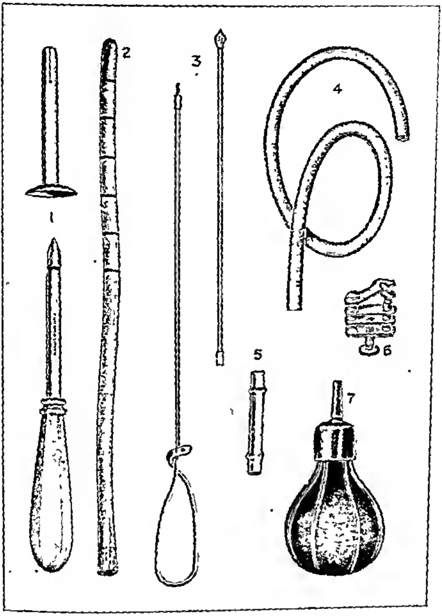
* For freeing periosteum on deep aspect.



LVI.—INSTRUMENTS FOR RIB RESECTION.



LVII.—LOBECTOMY INSTRUMENTS



LVIII.—INSTRUMENTS FOR DRAINAGE OF EMPYEMA
(Stuart's method)

PLATE LIX

1. **Volkmann's sharp spoons or curettes.** These are used mainly for scraping out tuberculous gland abscesses and abscess cavities in bone.

2. **Cummin's gland forceps** used in operations for removal of tuberculous glands. The ruged blades which have relatively sharp edges secure a firm hold, and can be applied to a softened gland without much risk of causing it to rupture.

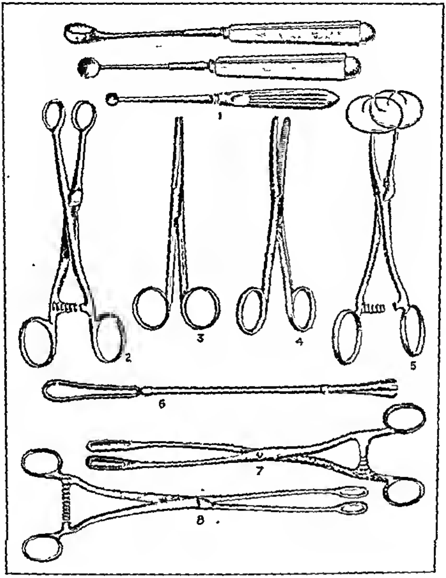
3. **Lister's sinus forceps.*** This has slender blades tapered and probe-pointed. It is used for exploring or swabbing out sinuses, or for opening abscesses by *Hilton's method.* This method is employed for the location of deep-seated pus, especially in the cervical region. A small incision is made through skin and fascia, and sinus forceps are pushed deeply in different directions until the abscess is located.

4. **Dressing forceps*** -used for lifting swabs, etc., in the dressing of wounds. The blades are much thicker than those of sinus forceps and are slightly curved.

5. **Kocher's goitre forceps.** The sharp spikes on the blades prevent slipping, so that a firm hold of the gland is obtained.

6 to 8. **Swab-holders.** Nos. 7 and 8 may be used as packing forceps.

* *Note the absence of a ratchet on the handles.*



LIX.—MISCELLANEOUS INSTRUMENTS

PLATE LX

1. **Martin's cartilage forceps** used for removal of a semilunar cartilage. The blades are fitted with large teeth which take a firm hold on the cartilage.

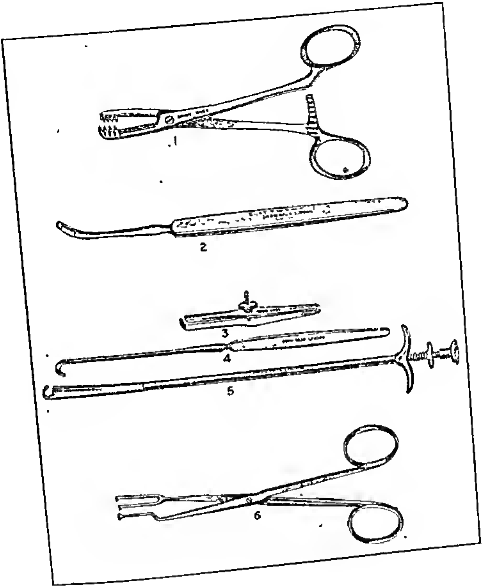
2. **Fairbank's cartilage knife.** This is a probe-pointed knife curved on the flat, with only a short cutting edge. It is used for freeing the cartilage from its attachments.

3. **Crile's carotid clamp**—used for temporary occlusion of the carotid and other large arteries.

4. **Rose's trigeminal nerve hook (knife).**
5. **Adson's trigeminal nerve guillotine.**

{ Used for dividing the sensory root of the nerve, or the branches of its ganglion.

6. **Wilkie's intestinal suturing forceps.** These are designed to facilitate the performance of intestinal anastomosis. The cut edge of bowel is gripped by the forceps, the single blade of which lies on the mucous surface. The edge is thus conveniently raised to receive the needle, which penetrates from serosa to mucosa, and from mucosa to serosa, in one thrust.



LX.—MISCELLANEOUS INSTRUMENTS

PLATE LXI

1. **Stomach tube***—used for evacuation of stomach contents, and for gastric lavage. Emptying of the stomach is obtained by syphonage.

2. **Ryle's duodenal tube.*** This is a fine tube with a weighted end, used for aspiration of stomach or duodenal contents, as in "test meal" and similar examinations. It can also be employed for continuous drainage of stomach and duodenum.

3. **Freyer's bladder drainage tube**—used for supra-pubic drainage of the bladder after prostatectomy.

4. **Paul's tube—large.**
5. **Paul's tube—small.**

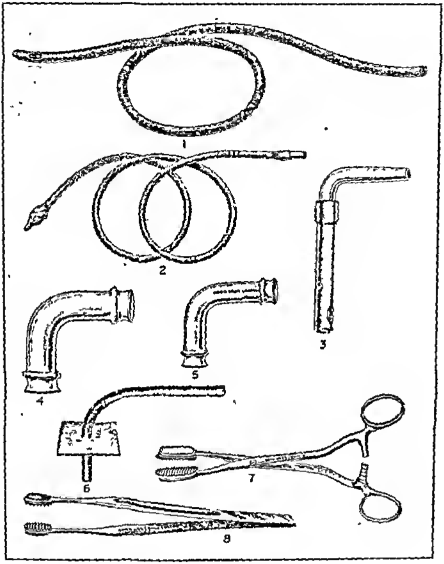
Used for drainage of the bowel (usually colon) in the treatment of obstruction. The tube may be tied into the cut end or side of the bowel which is brought out at the wound. By means of thin-walled rubber tubing (Paul's tubing), faecal matter is drained to a bottle at the patient's bedside.

6. **Empyema tube.** The rubber flange lies against the chest wall, and prevents entrance of air into the pleural cavity.

7. **Black's bowel-holding forceps.**
8. **Young's bowel-holding forceps.**

The rubber pads on the blades prevent injury to the bowel.

* These tubes may have circular markings on them at distances of 15" and 22" from the tip. As the 15" mark passes the front teeth, the tip of the tube should enter the stomach: at the 22" mark, it should lie at the pyloric sphincter.



LXI.—MISCELLANEOUS INSTRUMENTS

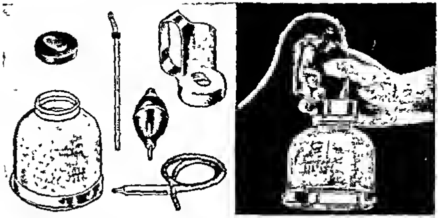


PLATE LXII

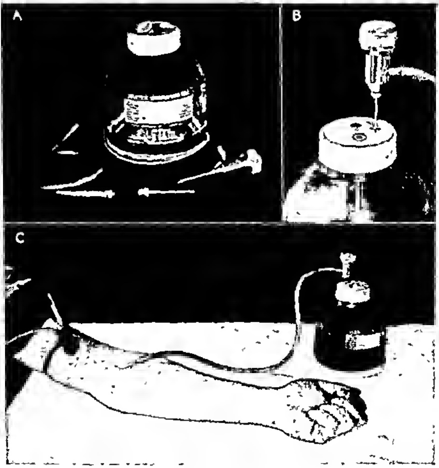


PLATE LXIII

LXII & LXIII.—BAXTER APPARATUS FOR BLOOD TRANSFUSION

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